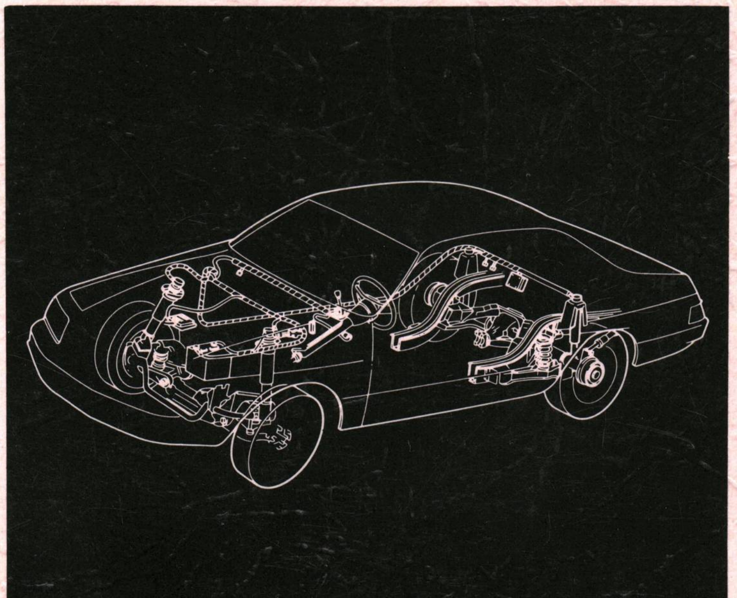
ELECTRONIC STEERING AND SUSPENSION SYSTEMS



Ford Parts and Service Division
Technical Training

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, AND WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual or the Shop Manual and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual or the Shop Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

WARNING: Many brake linings contain asbestos fibers. When working on brake components, avoid breathing the dust. Breathing the asbestos dust can cause asbestosis and cancer.

Breathing asbestos dust is harmful to your health.

Dust and dirt present on car wheel brake and clutch assemblies may contain asbestos fibers that are hazardous to your health when made airborne by cleaning with compressed air or by dry brushing.

Wheel brake assemblies and clutch facings should be cleaned using a vacuum cleaner recommended for use with asbestos fibers. Dust and dirt should be disposed of in a manner that prevents dust exposure, such as sealed bags. The bag must be labeled per OSHA instructions and the trash hauler notified as to the contents of the bag.

If a vacuum bag suitable for asbestos is not available, cleaning should be done wet. If dust generation is still possible, technicians should wear government approved toxic dust purifying respirators.

OSHA requires areas where asbestos dust generation is possible to be isolated and posted with warning signs. Only technicians concerned with performing brake or clutch service should be present in the area.

Produced and Coordinated by
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Training and Publications Department
Ford Parts and Service Division

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FORD ELECTRONIC STEERING AND SUSPENSION SYSTEMS

The content of this Comprehensive Training Program Manual has been compiled by the Ford Parts and Service Division. It provides information on the design, diagnosis and service of Ford Electronic Steering and Suspension Systems to assure technician understanding of these automotive design concept.

This manual is intended for use by technicians involved in automotive service that includes steering and suspension systems. For additional information on servicing and testing Ford Electronic Steering and Suspension Systems refer to the Ford Shop Manual for the vehicle model involved.

This CTP Manual is divided into 2 major sections. The first covers Electronic Steering, the second covers Electronic Suspension. Each section is divided into segments covering different topics that relate to Steering or Suspension including descriptions of each system along with pertinent diagnostic techniques.

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ELECTRONIC STEERING SYSTEMS

Conventional power steering systems are designed to provide the driver of a vehicle with a certain degree of assist to help in turning the steering wheel. This can be of great help during low speed driving, parking and evasive maneuvers at any speed. A disadvantage of power steering is the fact that drivers have reduced road feel, especially at medium to high speeds where it is desirable for a feeling of increased control and performance. Conventional power steering systems are typically compromises between these two extremes. If they provide high power assist, there is reduced road feel; if they provide excellent road feel there is reduced power assist. Through the utilization of electronic controls on the power steering system, the best of both worlds can be attained.

Electronic steering systems are basically steering systems that contain a solid state device that in some manner controls the rate of power assist provided to the driver. The solid state device is typically called a module and is mounted somewhere within the vehicle, not on the steering gear.

There are several methods used to vary the amount of power assist. These are discussed in the descriptions of the different systems. Similarities in the systems are primarily in the basic type of steering system used and the information required by the control module to determine how much assist is required.

BASIC POWER STEERING SYSTEMS

Power steering systems can be divided into two types based on the style of steering gear utilized. The two basic types of steering gears are:

- **Recirculating Ball**
- **Rack and Pinion**

Recirculating Ball Steering System

The recirculating ball type steering gear (Fig. 1) was, at one time, the exclusive style of steering gear. Now it sees its primary use on light trucks and some larger passenger cars.

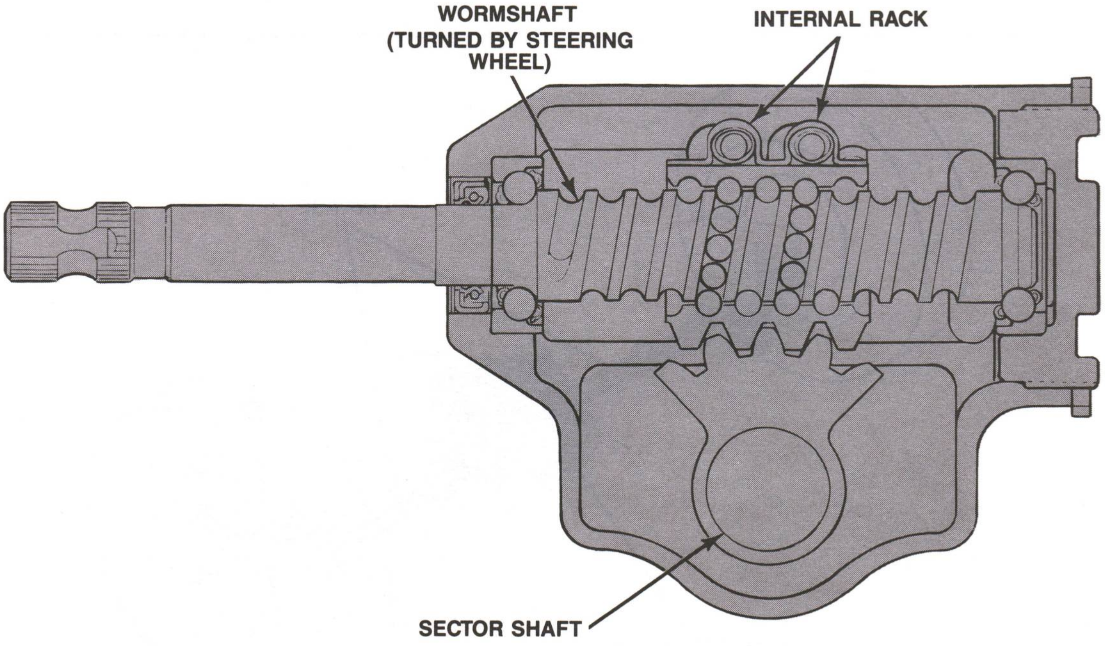


Figure 1 — Recirculating Ball Type Steering Gear

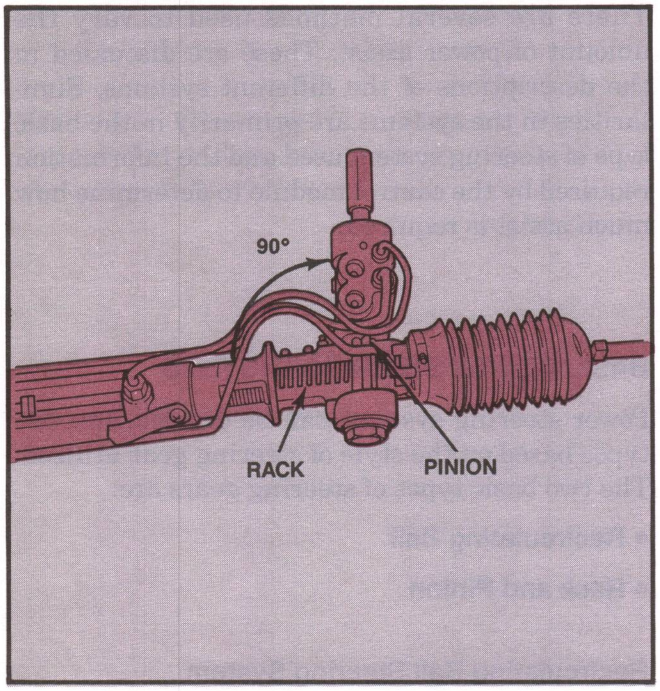


Figure 2 — Rack and Pinion Steering Gear

This steering gear is fairly complex. It converts rotary motion from the steering wheel to linear motion on an internal rack, which in turn converts the motion back to rotary motion for the sector shaft.

Rack and Pinion Steering Gear

The rack and pinion steering gear (Fig. 2) is a simpler design than the recirculating ball type gear. This simplicity can be attributed to fewer parts and that the rotary motion of the steering wheel is turned into linear motion by the rack and pinion. Note that the pinion gear is at an approximate right angle to the steering rack. As it turns, the gear output becomes linear.

A special point about the rack and pinion design is that it reduces the amount of linkage required to complete the attachment to the front wheels. The illustration shown above includes the tie rod ends, which attach directly to the steering knuckles. This is a much simpler linkage than is typically required for a recirculating ball type steering gear system (Fig. 3).

All current Ford Motor Company electronic steering systems use the rack and pinion steering system. The basic reason for this is that because electronics in themselves are very precise. They require a precise steering system with very little play or clearance to reach their full designed potential. The rack and pinion steering system fits this requirement.

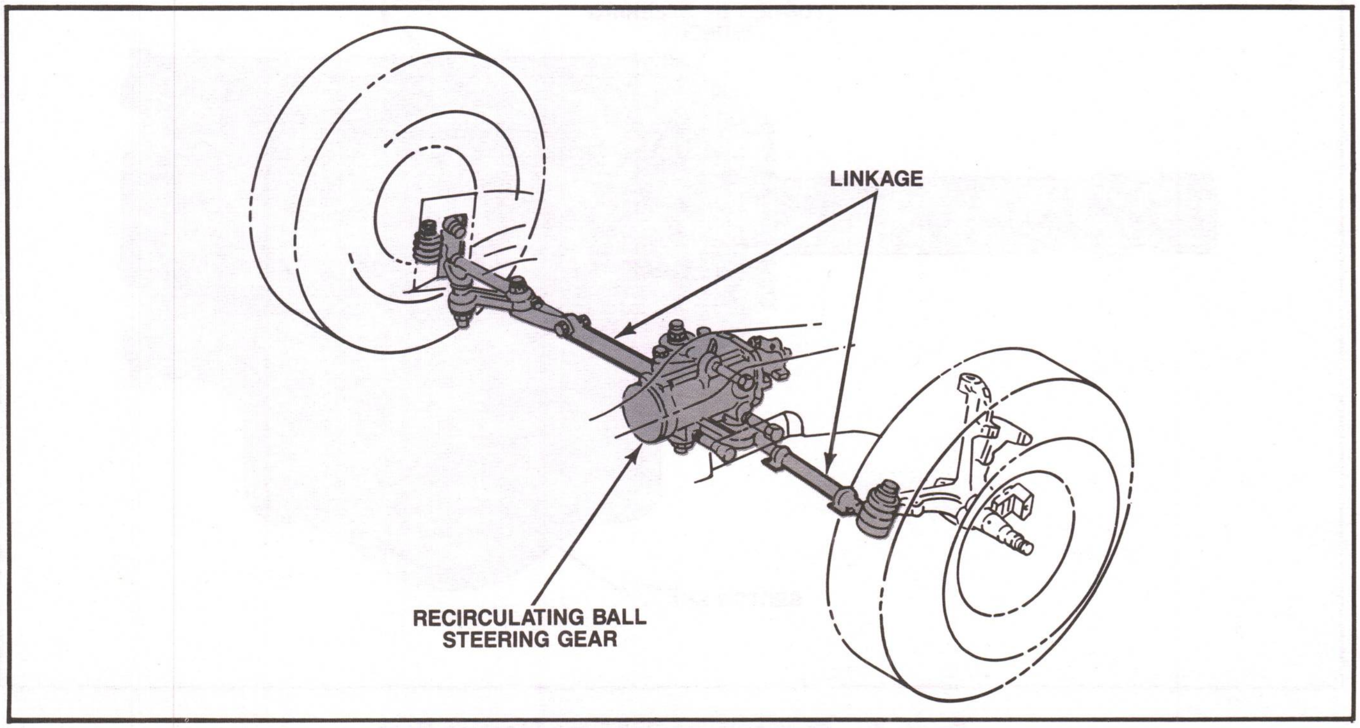


Figure 3 — Conventional Steering Linkage

ADAPTATION OF COMPUTER CONTROL ON POWER STEERING

The adaptation of computer control to steering is meant to accomplish two basic customer needs. They are:

1. Provide positive road feel at high speeds, in effect reducing the amount of power assist.
2. Provide full assist when the driver needs it. This could occur at low or high speed. For example, full assist is needed at low speed during parking. At high speed full assist would be desirable during evasive maneuvers.

The primary components of the system are input sensors, a module and output devices (Fig. 4). The inputs sensors provide information to the module which in turn makes steering related decisions which are put into effect by the actuating device.

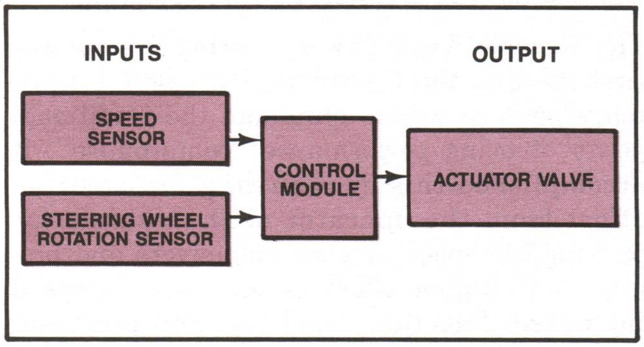


Figure 4 — Basic Steering System Schematic

Module Function and Primary Input Devices

The primary duty of the module (Fig. 5) that controls the steering system is to determine how much assist is required by the driver. To perform this function, the module must receive very specific information. The primary input to the steering system control module is vehicle speed. This is because increased assist is generally desirable at low speed and reduced assist is desirable as speed increases to provide improved road feel. To determine the amount of assist the module must know how fast the vehicle is travelling.

This signal is supplied by a speed sensor which sends an output current to the computer that changes linearly with speed. The faster the sensor turns, the higher the milli-amp output. On the other hand, as speed is reduced the current decreases at the same linear rate.

Generally, the speed sensor is mounted at the output of the transmission or transaxle.

NOTE: On the Probe GT, the speed sensor is integral with the speedometer in the instrument cluster.

In addition to speed there can be another input for steering and that is steering wheel rotation. A point to note is that not all Ford electronic steering applications use this input.

The steering wheel rotation input informs the module of steering wheel position so that it can calculate lateral acceleration. Also, it informs the module of the steering wheel turning rate providing an input that indicates when the steering wheel is turned rapidly, such as during a high speed evasive maneuver. Increased assist would be desirable during instances of high lateral acceleration or rapid steering wheel rotation.

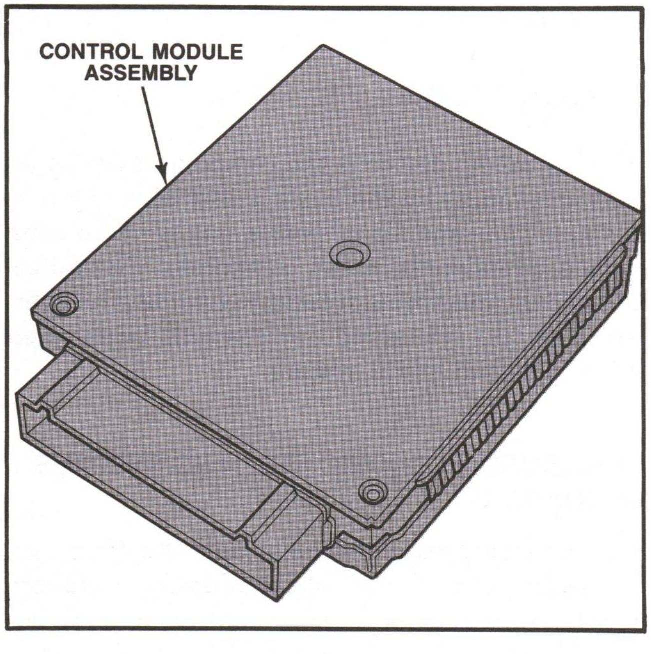


Figure 5 — Steering System Control Module

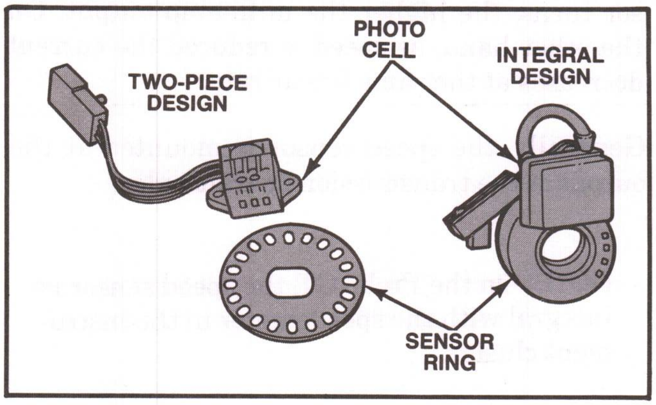


Figure 6 — Steering Wheel Rotation Sensors

Steering wheel sensors (Fig. 6) are optical photo cells that measure the rate at which the steering wheel is turned and can also determine when the steering wheel is in its center position. The rate of steering wheel movement is measured when the sensor ring slits go past the photo cell. The output signal to the module is low when there is slow steering wheel movement. If steering wheel movement is rapid, the output signal increases linearly with steering wheel RPM.

The steering wheel sensor is mounted in the steering column. Note that some steering sensors have the photocell and sensor ring as an assembly and others have the photocell and ring as separate pieces.

Actuating Devices

The actuating device is the component that puts decisions made by the module into effect by controlling the amount of power assist. Actuating devices are also the major component that differentiate the electronic steering systems. The operation of the actuating devices will be covered with each individual system.

CURRENT ELECTRONIC STEERING SYSTEMS OPERATION

This section covers the electronic steering systems currently offered by Ford Motor Company. The systems are:

- **Variable Assist Power Steering (VAPS) — First introduced on the 1988 Lincoln Continental.**
- **Speed Sensitive Variable Assist (EVO) Power Steering — Originally introduced on the 1989 Thunderbird and Cougar models. EVO stands for Electronic Variable Orifice.**
- **Variable Assist Power Steering — Originally introduced on the 1989 Probe GT.**

Basically there are two methods of electronically controlling steering. The first utilizes actuating devices mounted on the steering gear. This type of system is found on the Continental and Probe GT. The second type of system relies on an actuating device mounted on the power steering pump. This type of system is found on the Thunderbird/Cougar models.

Continental Variable Assist Power Steering

The Variable Assist Power Steering System was first used on the Continental in 1988. Its primary purpose was to eliminate the traditional power steering performance "compromise". It accomplished this by requiring low steering effort from the operator of the vehicle for parking/low speed driving maneuvers and progressively higher effort as the vehicle's speed increased. Excellent road feel and precision steering response were a direct result of the implementation of this system.

Description

The Variable Assist Power Steering System is comprised of a microprocessor-based electronic control module, a special power rack-and-pinion steering gear, and an actuator valve assembly mounted on the power steering gear. The steering gear contains a modified conventional rotary valve in the steering gear, except that the valve has two independent hydraulic circuits (primary and secondary. If you are unsure of the purpose of the rotary valve in the steering gear, the following note provides an explanation.

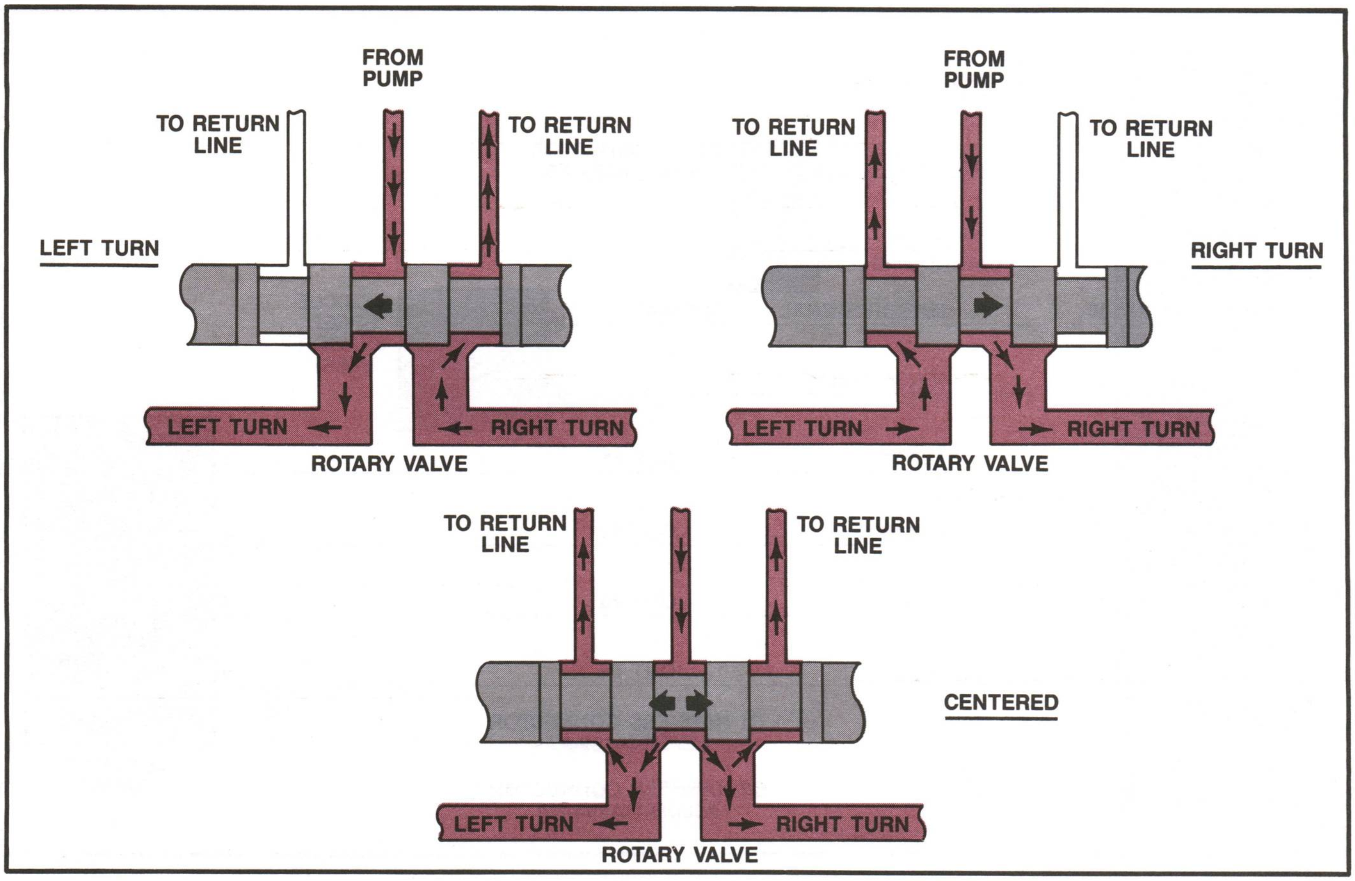

FROM PUMP
TO RETURN LINE
TO RETURN LINE
LEFT TURN
LEFT TURN
RIGHT TURN
ROTARY VALVE
FROM PUMP
TO RETURN LINE
TO RETURN LINE
RIGHT TURN
LEFT TURN
RIGHT TURN
ROTARY VALVE
TO RETURN LINE
TO RETURN LINE
CENTERED
LEFT TURN
RIGHT TURN
ROTARY VALVE

Figure 7 — Typical Rotary Valve Operation

NOTE: All Ford steering gears use a rotary valve to direct hydraulic flow to the pistons within the steering gear. The valve consists of an inner and outer spool and a torsion bar that reacts to the movement of the steering wheel (Fig. 7) When the steering gear is in the straight-ahead position, the rotary valve is centered. Hydraulic flow from the pump enters the outer valve body from the housing ports. The valve spool is positioned so that the ports to both the left and right return passages are open. This maintains a constant pressure on both sides of the piston to aid in absorbing road shock. The ports are also open to the fluid return circuit so a continuous flow is maintained in the system.

When the steering wheel is turned to the left, the torsion bar twists, allowing the spool to change position relative to the valve body. When this occurs, the lands on the spool restrict hydraulic flow to the right turn side of the piston and open the circuit to the return line. At the same time, the left turn supply port is opened wider and the return port is partially cut off. This restricts flow from the pump causing system pressure to rise. A pressure differential is created on either side of the piston that forces the piston to move in the direction of steering wheel rotation. This movement is felt by the driver as a reduction in turning effort.

When the steering wheel is released, the valve spool returns to center. Pressure on either side of the piston equalizes allowing vehicle momentum and front end geometry to force the piston back to its centered position. When the wheel is turned to the right, the process is reversed to apply the pressure advantage to the right turn side of the piston.

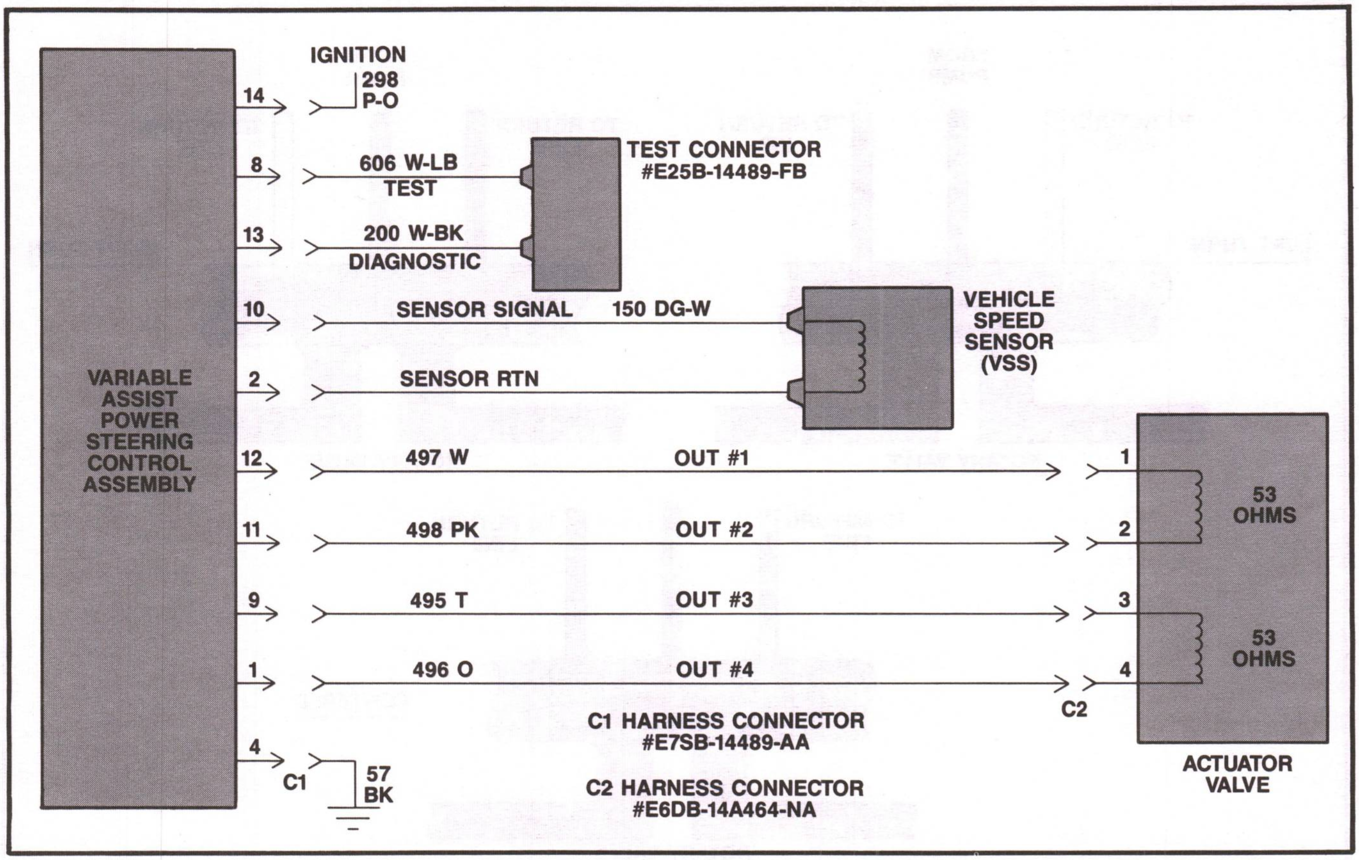

VARIABLE ASSIST POWER STEERING CONTROL ASSEMBLY
14
IGNITION
298 P-O
8
606 W-LB
TEST
TEST CONNECTOR #E25B-14489-FB
13
200 W-BK
DIAGNOSTIC
10
SENSOR SIGNAL
150 DG-W
VEHICLE SPEED SENSOR (VSS)
2
SENSOR RTN
12
497 W
OUT #1
11
498 PK
OUT #2
9
495 T
OUT #3
1
496 O
OUT #4
1
2
3
4
53 OHMS
53 OHMS
C2
ACTUATOR VALVE
4
C1
57 BK
C1 HARNESS CONNECTOR #E7SB-14489-AA
C2 HARNESS CONNECTOR #E6DB-14A464-NA

Figure 8 — Variable Assist Power Steering System Electrical Schematic

Operation

During parking and low speed maneuvers, the flow from the pump is routed entirely through the primary circuit by an electrically controlled actuator valve assembly. As the vehicle's speed increases, the actuator valve gradually opens. This allows an increasing amount of fluid flow to be diverted to the secondary circuit which varies the steering effort required by the operator. This valve is really two valves built into one. A high effort valve, for high vehicle speeds, and a low effort valve, for low vehicle speeds are combined to provide the varying steering assist levels.

A computer module controls the actuator assembly based on input from the vehicle speed sensor. The actuator assembly then uses an electric stepper motor to vary the position of the spool valve. This directs fluid flow to either the primary or secondary inlet ports. The variable assist is programmed to change gradually from low efforts to high efforts between approximate vehicle speeds of 10 and 55 MPH. The variation in vehicle steering efforts will be perceived as a continuous function by the operator.

As an added feature, the Variable Assist Power Steering module is programmed to perform a self diagnostic check at specific intervals. When a problem is detected, the module microprocessor deactivates and allows normal power steering operation. The module is mounted to the steering column support bracket.

An important point to note is that the major input to the module is provided by the vehicle speed sensor (Fig. 8). A sensor that monitors steering wheel rotation is not utilized for steering (there is one for the suspension system).

Probe GT Variable Assist Power Steering System

The Probe GT Variable Assist Power Steering System is similar to the Continental only in that the actuating device is mounted on the steering gear. The steering effort required is determined according to the oil pressure applied to the reaction force chamber on the steering gear actuating device (Fig. 9)

The pressure within the reaction force chambers is determined by the control module through a solenoid valve (also mounted on the steering gear). The control module determines how much steering assist is required through inputs from a speed and steering wheel rotation sensor.

Operation

Power steering fluid is fed into the actuator where it flows to the reaction force chamber and through an orifice to the solenoid valve. At the same time the fluid is fed into the reserve tank or power cylinder according to the movement of the spool valve. The solenoid valve then controls the fluid to the reserve tank.

When the pinion gear is rotated, the lever pivots. Consequently the spool valve is moved, overcoming the spring pressure and pressure in the reaction force chamber. Note that the steering effort to the driver is influenced by the amount of pressure within the reaction force chambers — Not by the overall fluid pressure applied to the steering gear piston.

Actuating Device

The actuating device (or control valve) consists of the following items:

- **Valve case**
- **Spool Valve**
- **Lever**
- **Reaction Force Chambers and Springs**
- **Pinion Shaft**

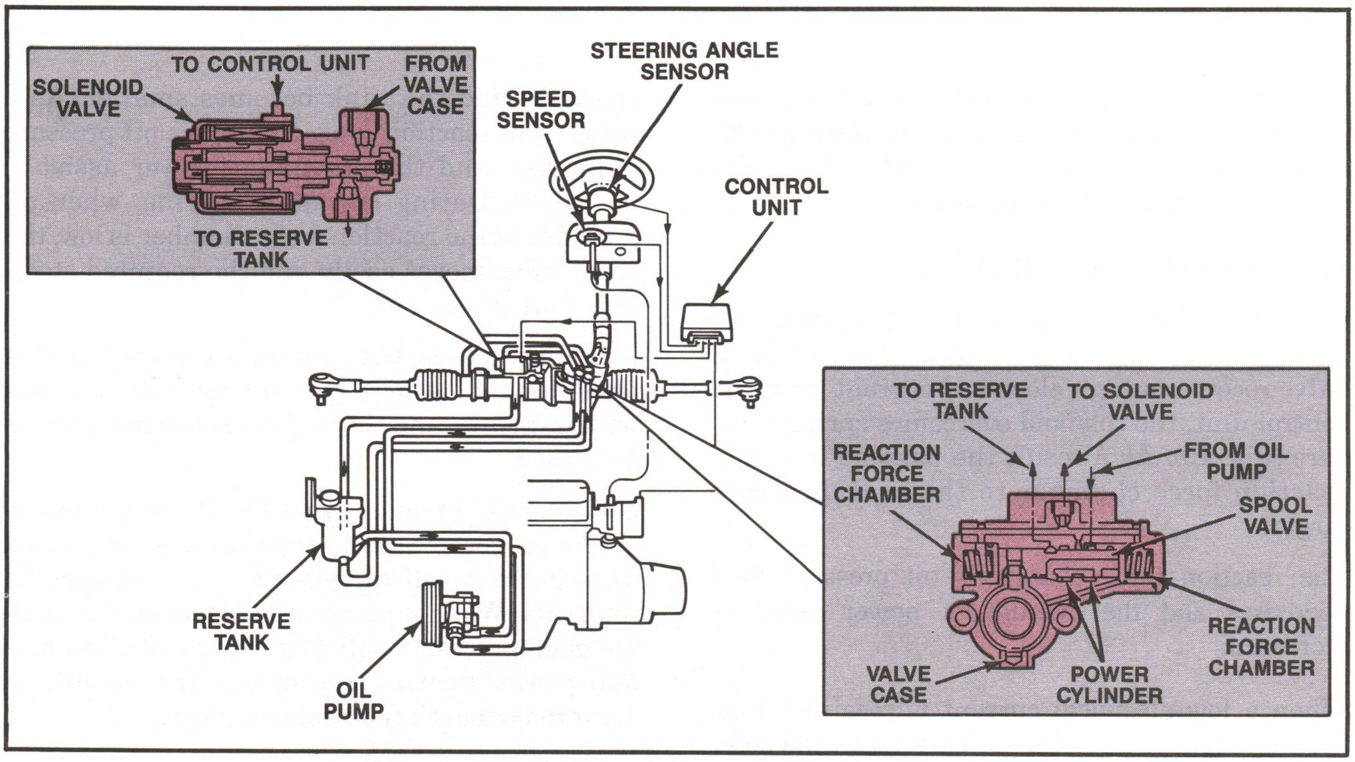

TO CONTROL UNIT
FROM VALVE CASE
SOLENOID VALVE
TO RESERVE TANK
SPEED SENSOR
STEERING ANGLE SENSOR
CONTROL UNIT
TO RESERVE TANK
TO SOLENOID VALVE
REACTION FORCE CHAMBER
FROM OIL PUMP
SPOOL VALVE
REACTION FORCE CHAMBER
VALVE CASE
POWER CYLINDER
RESERVE TANK
OIL PUMP

Figure 9 — Probe GT Variable Assist Power Steering System

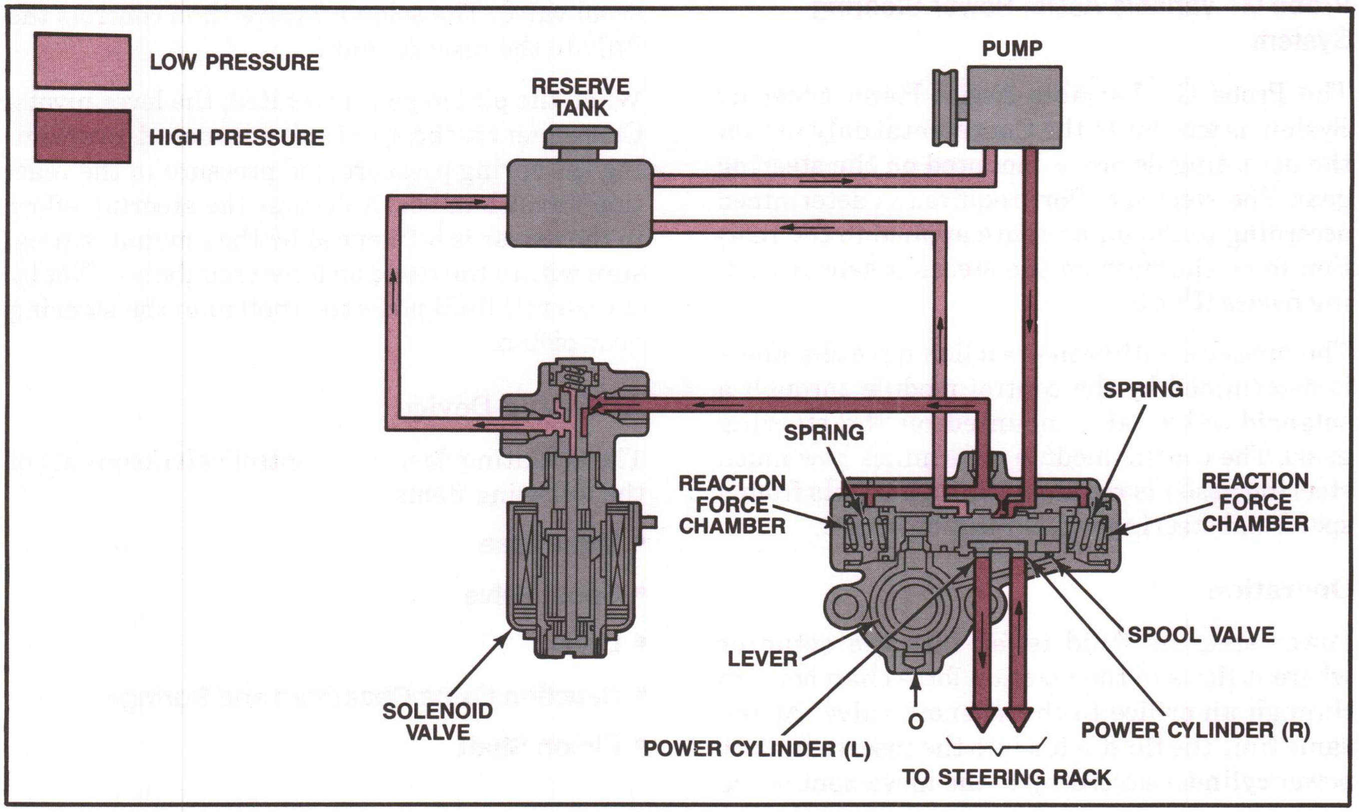

LOW PRESSURE
HIGH PRESSURE
RESERVE TANK
PUMP
SPRING
SPRING
REACTION FORCE CHAMBER
REACTION FORCE CHAMBER
SPOOL VALVE
LEVER
O
SOLENOID VALVE
POWER CYLINDER (L)
POWER CYLINDER (R)
TO STEERING RACK

Figure 10 — Steering Gear System Operation

The spool valve is connected to the pinion shaft by the lever. The springs and pressure in the reaction force chambers are used to keep the spool valve in its neutral position.

Solenoid Valve Operation

The solenoid valve controls fluid pressure in the reaction force chambers. When the solenoid valve receives a high electrical current from the control unit, the solenoid overcomes spring pressure (Fig. 10). As a result the passage from the reaction force chamber to the tank becomes larger.

The reaction force chamber's oil pressure then decreases and the amount of power assist is increased.

When a low electrical current is received from the module, spring pressure overcomes the solenoid, and the passage between the reaction force chamber and the tank becomes smaller. As a result, the reaction force chamber's oil pressure increases, and the amount of power assist is decreased. During low speed driving, when oil pressure in the reaction force chamber is low, the spool valve moves easily and the required steering effort is lessened.

At higher speeds, the oil pressure of the reaction force chamber is increased, the spool valve moves with difficulty, and the required steering effort is increased.

A final point to note is that the Probe GT Variable Assist Power Steering module is programmed to perform a self diagnostic check at specific intervals. When a problem is detected, the module microprocessor will deactivate and allow normal power steering operation. The module is mounted beneath the passenger seat.

Thunderbird/Cougar EVO Steering System

For the 1989 model year all Thunderbird and Cougar models except for the base Thunderbird feature a new speed-sensitive electronic variable assist power rack and pinion steering system. This system provides much improved steering feel compared to the design used in previous models. The system is referred to as the EVO. This is because of the Electronic Variable Orifice that is the controlling component of power steering flow. The fact that the EVO is placed on the power steering pump sets it apart from the Continental and Probe GT, both of which have the actuating device on the steering gear.

System Description

System operation is similar to both the Continental and Probe GT in that the system provides the driver with increased steering effort at high speeds for improved road feel. At low speed steering effort is reduced to provide for improved low-speed maneuvering, such as parking. In the EVO system, full steering assist is provided at low speed. As speed increases, steering effort is increased throughout the entire driving range, all the way up to 80 miles per hour (above 80 miles per hour, effort becomes constant).

The objective of the EVO system is to adjust the steering effort for optimized feel. This is accomplished through the use of the EVO device on the power steering pump. With the EVO, steering effort is continually calculated based on vehicle speed. Some important points to note about the system include:

- **Full assist is returned at higher speeds during evasive maneuvers.**
- **A "fail safe" feature is designed into the EVO system. In the event of an electrical circuit malfunction, such as circuit open, shorted, or controller failure, etc., the EVO provides full power steering assist during such failure modes. A point to note is that prolonged operation under such conditions may cause excessive system temperature and may overheat the system.**
- **Service diagnostics are designed into the control module to provide for greater ease in troubleshooting.**

Major Components

The EVO system is made up of a control module that receives information from a speed sensor and a steering wheel rotation sensor. The control module processes this information and signals the actuator (EVO) as to the amount of assist required. The EVO in turn varies the flow from the CII power steering pump to provide variable assist.

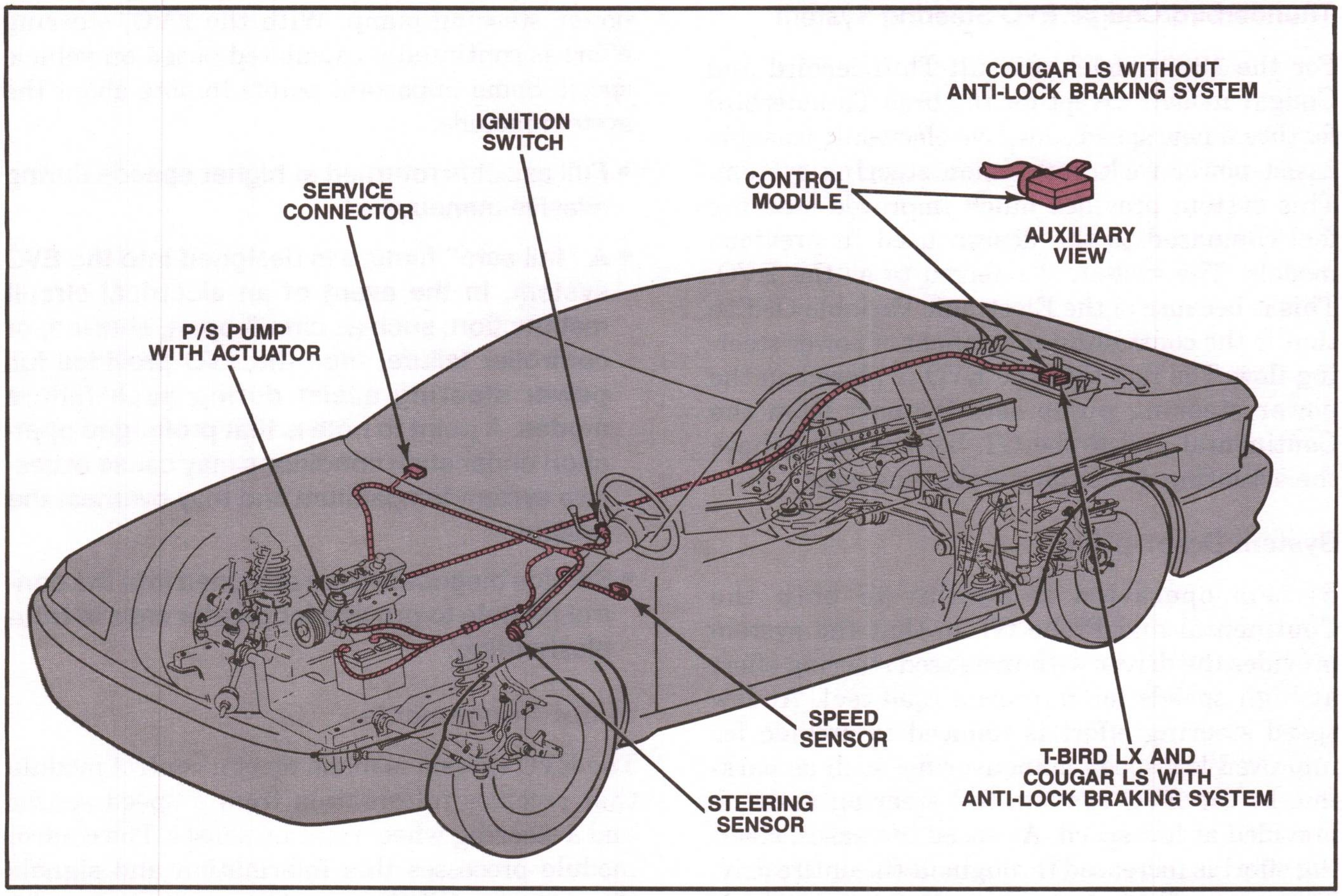

COUGAR LS WITHOUT ANTI-LOCK BRAKING SYSTEM
IGNITION SWITCH
CONTROL MODULE
SERVICE CONNECTOR
AUXILIARY VIEW
P/S PUMP WITH ACTUATOR
SPEED SENSOR
T-BIRD LX AND COUGAR LS WITH ANTI-LOCK BRAKING SYSTEM
STEERING SENSOR

Figure 11 — System Component Locations

The major components (Fig. 11) include:

- **EVO Actuator Assembly — Attached to the CII power steering pump.**
- **Steering Wheel Rotation Sensor — Lower steering column.**
- **Vehicle Speed Sensor — On tailshaft of transmission.**
- **Service Diagnostic Connector — Upper glove compartment (Thunderbird LX and Cougar LS only).**

  NOTE: The EVO system in the Thunderbird Super Coupe and Cougar XR7 is integrated with the Automatic Ride Control System. Use the Programmed Ride Control System diagnostic connector to access codes for the EVO system. The diagnostic connector is located beneath the hood on the right shock tower.

- **Control Module — Located in the Luggage Compartment on Thunderbird LX and Cougar LS with Anti-Lock Braking System — Inside the module tray, located in the luggage compartment, behind the driver's side back seat.**

  — Cougar LS without Anti-Lock Braking System -

  Mounted with a bracket under the left rear speaker opening, immediately below the package tray.

  — Thunderbird Super Coupe and Cougar XR7 -

  This control module is integrated with the Automatic Ride Control System. The Control module is located in the luggage compartment on the module tray.

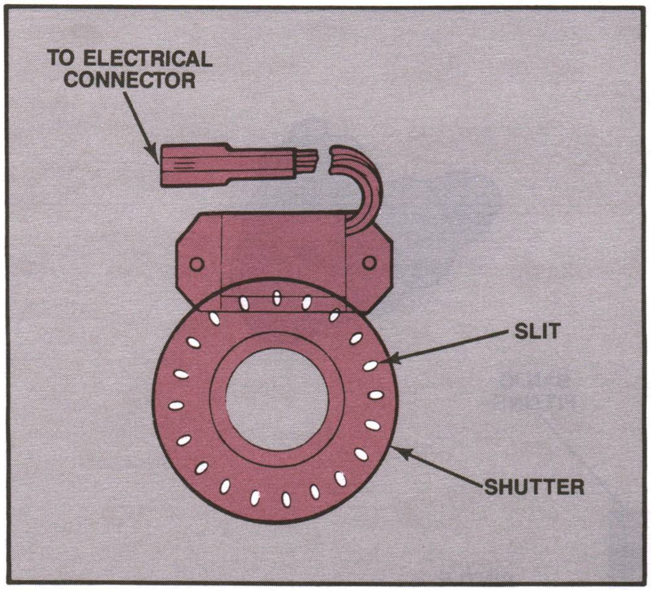


Figure 12 — Steering Wheel Rotation Sensor

Component Descriptions

Steering Wheel Rotation Sensor (Fig. 12) — This sensor is an optical photo cell, mounted on the steering column and is used to establish the rate of the steering wheel rotation. When the steering wheel rotation rate reaches 15 RPM (revolutions per minute), the output current to the EVO actuator begins to reduce, thereby providing additional power steering assist. Once the steering wheel rotation rate reaches 100 RPM or greater, the output current to the actuator reaches zero, and full power steering assist is provided. After the steering wheel rotation rate drops below 15 RPM, the output current returns to the amount of current regulated by the speed sensor input, within one second. In addition to the EVO system , the steering wheel rotation sensor is used in the Automatic Ride Control System (Super Coupe and XR7).

Vehicle Speed Sensor (Fig. 13) — The vehicle speed sensor is also used as an input in the Automatic Ride Control System and is located on the transmission. It is used to establish the vehicle speed. The output current to the EVO actuator is a function of vehicle speed and the steering wheel rotation rate. When vehicle speed is 5 mph or less, the actuator output current is 0 mA (milliamps) and full steering assist is provided. As the vehicle speed increases to 20 MPH, the current increases linearly to 225 mA. As the vehicle speed continues to increase up to 80 MPH, the current increases linearly to 550 mA. The current then remains constant at 550 mA. for vehicle speed greater than 80 MPH. Conversely, as vehicle speeds decrease the current decreases at the same linear rate.

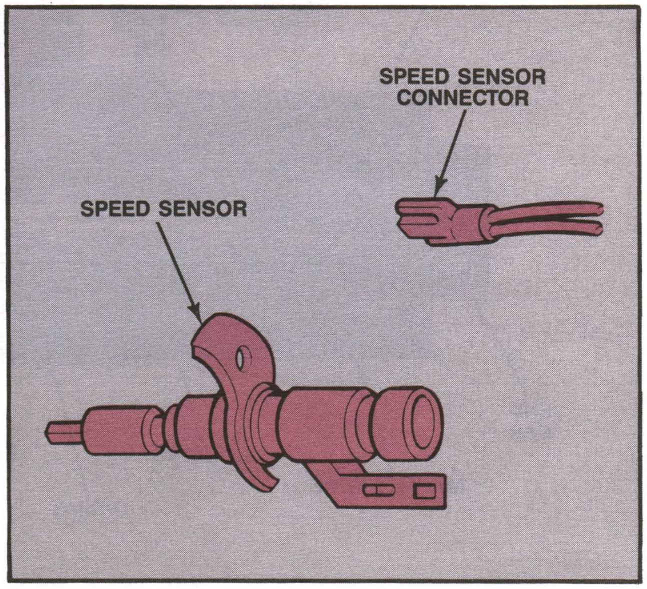


Figure 13 — Vehicle Speed Sensor

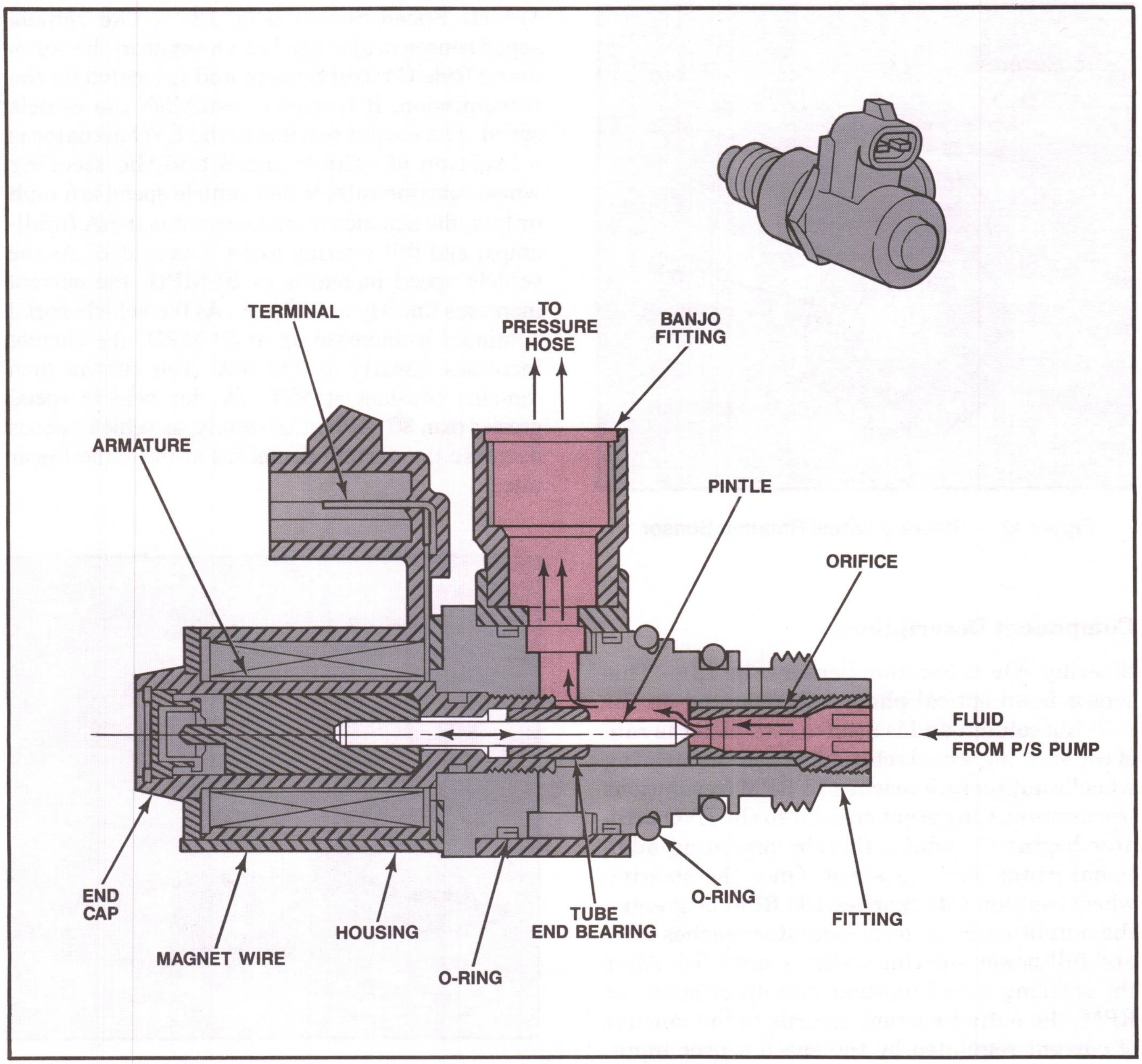

TERMINAL
TO PRESSURE HOSE
BANJO FITTING
ARMATURE
PINTLE
ORIFICE
FLUID FROM P/S PUMP
END CAP
MAGNET WIRE
HOUSING
O-RING
TUBE END BEARING
O-RING
FITTING

Figure 14 — EVO Actuator Assembly

EVO Actuator Assembly (Fig. 14) — The actuator generates a differential pressure, dependent on flow and current input. This differential pressure is used to control the spool valve in the present Ford CII power steering pump. The actuator assembly replaces the Power Steering Pump Valve Outlet (3D593). The actuator/spool valve regulates the hydraulic flow and when combined with a current controlling device yields a variable assist power steering system.

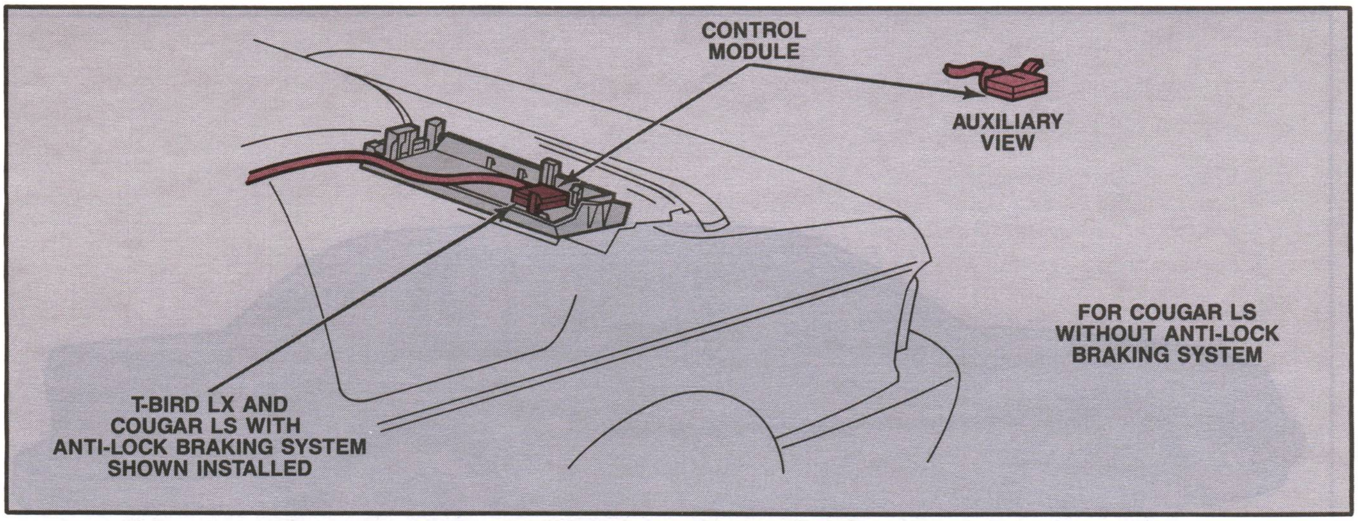

CONTROL MODULE
AUXILIARY VIEW
FOR COUGAR LS WITHOUT ANTI-LOCK BRAKING SYSTEM
T-BIRD LX AND COUGAR LS WITH ANTI-LOCK BRAKING SYSTEM SHOWN INSTALLED

Figure 15 — Control Module

Control Module (Fig. 15) — The control module contains a microprocessor which analyzes the vehicle speed sensor input and steering wheel rotation sensor input continuously. With this information, the microprocessor controls the actuator valve, thereby regulating the fluid flow from the power steering pump.

At low vehicle speeds (5 MPH or less), the actuator valve is controlled to provide full pump flow for full power steering assist (Fig. 16). At higher vehicle speeds, the actuator valve is controlled to reduce pump flow and reduce the power steering assist. For evasive maneuvering at high speeds (steering wheel rotation rate goes above 15 RPM), the actuator valve is controlled to increase the pump flow, thereby increasing power steering assist.

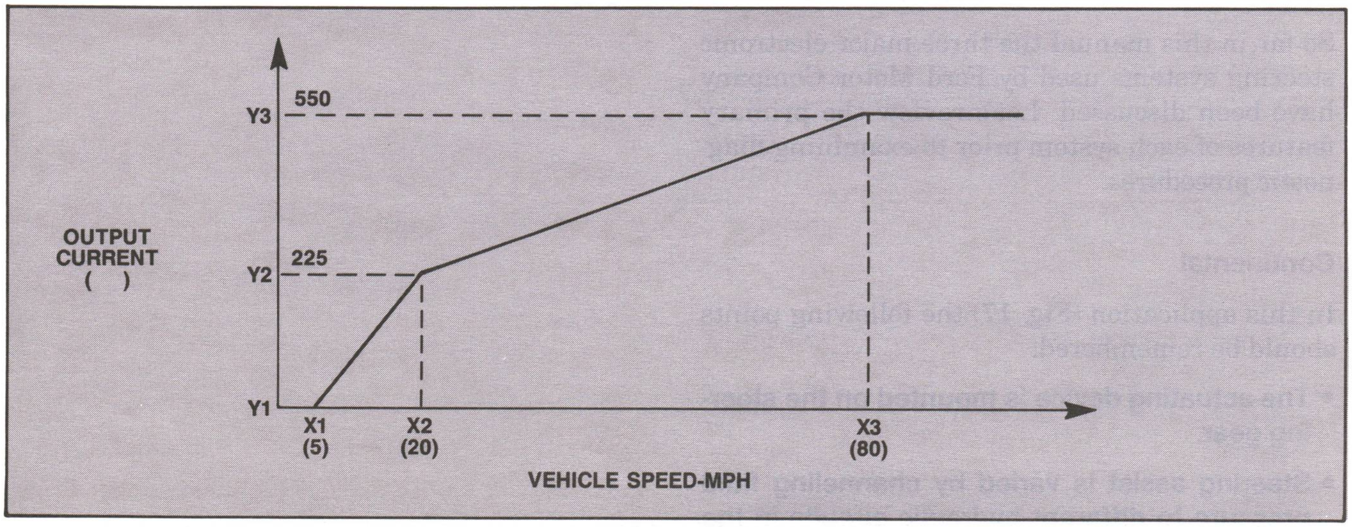


Figure 16 — Vehicle Speed vs Actuator Output

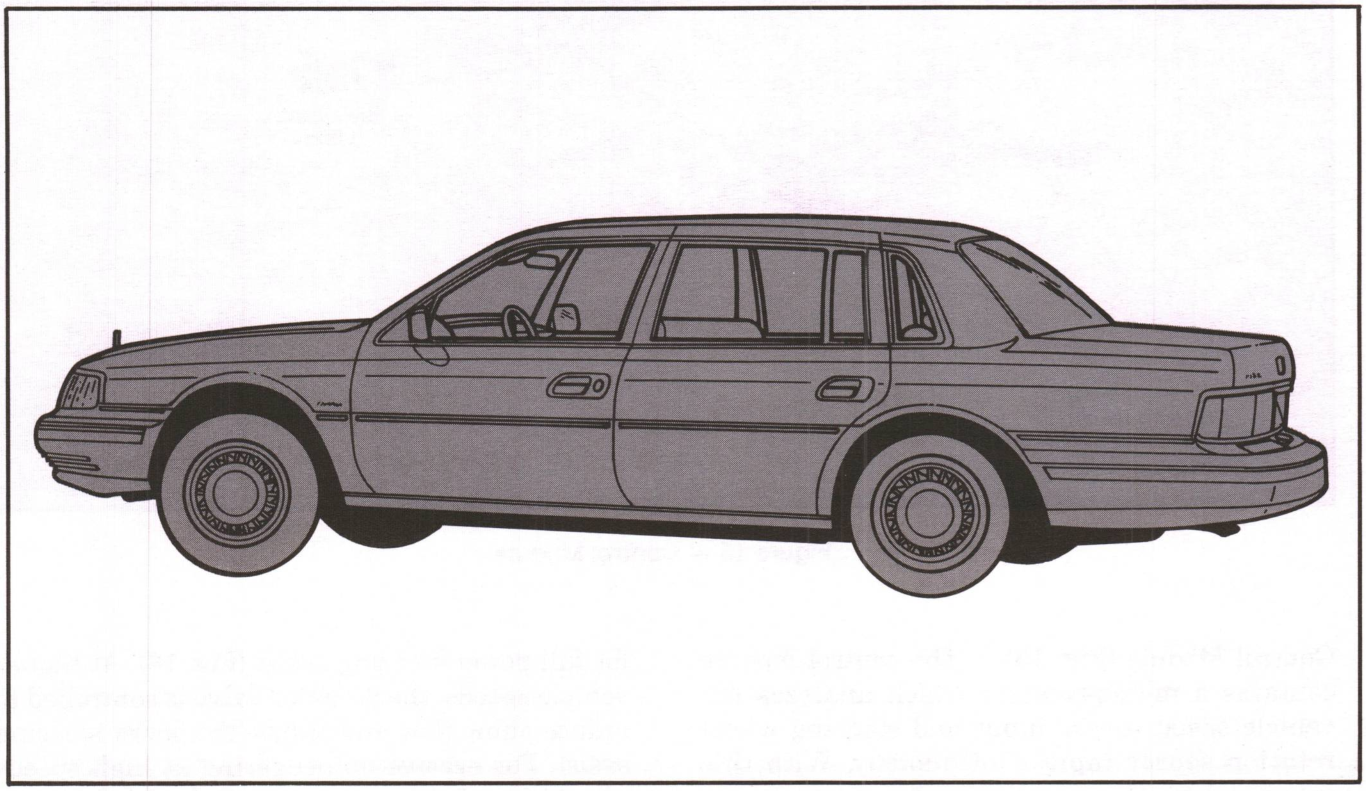


Figure 17 — Continental

CONCLUSION OF SYSTEM DESCRIPTIONS

So far in this manual the three major electronic steering systems used by Ford Motor Company have been discussed. Let's review the primary features of each system prior to examining diagnostic procedures.

Continental

In this application (Fig. 17) the following points should be remembered:

- **The actuating device is mounted on the steering gear.**
- **Steering assist is varied by channeling fluid pressure to different hydraulic circuits in the steering gear.**
- **Steering assist is based only on vehicle speed.**

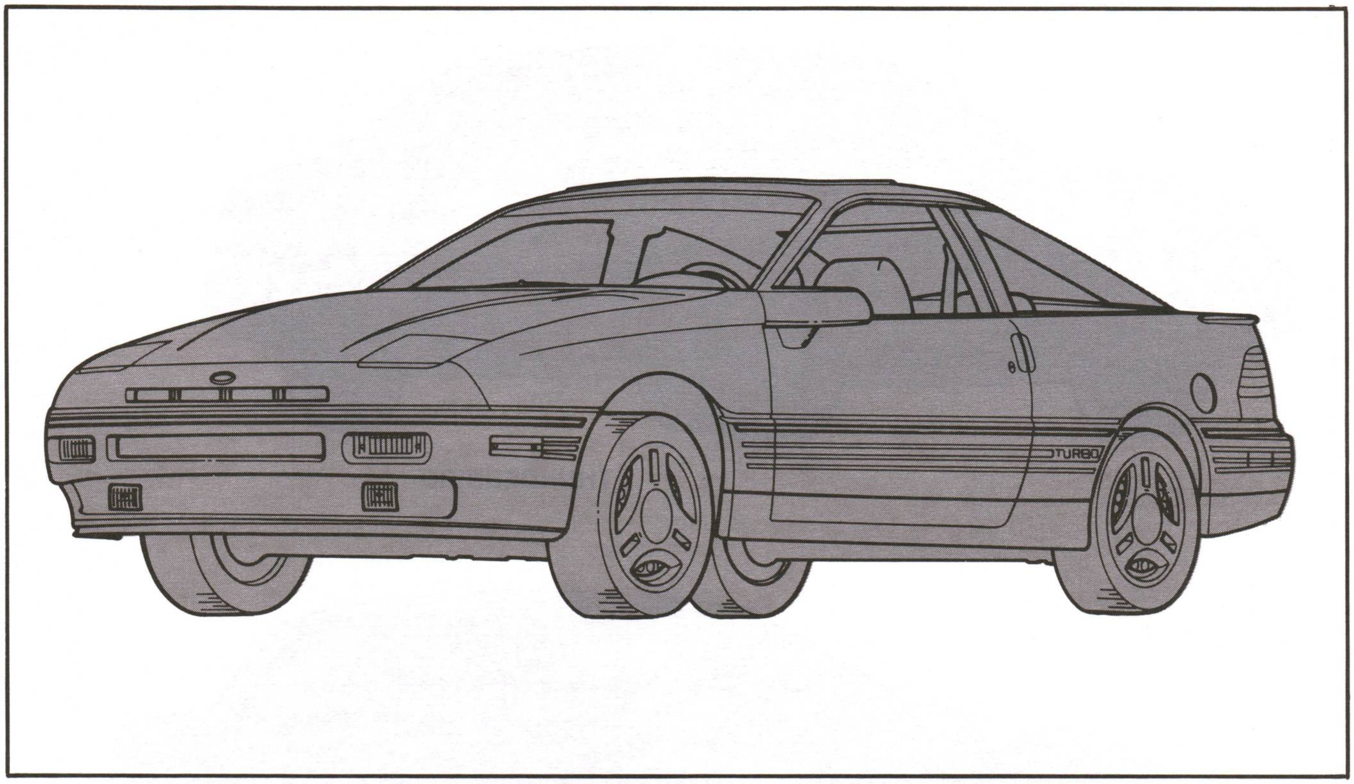


Figure 18 — Probe GT

Probe GT

In this application (Fig. 18) the following points should be remembered:

- **The actuating device is mounted on the steering gear.**
- **Steering assist is varied by bleeding fluid at different rates from the reaction chambers in the actuator.**
- **Fluid pressure to the steering gear is not regulated by the actuating device.**
- **Steering assist is based on vehicle speed.**

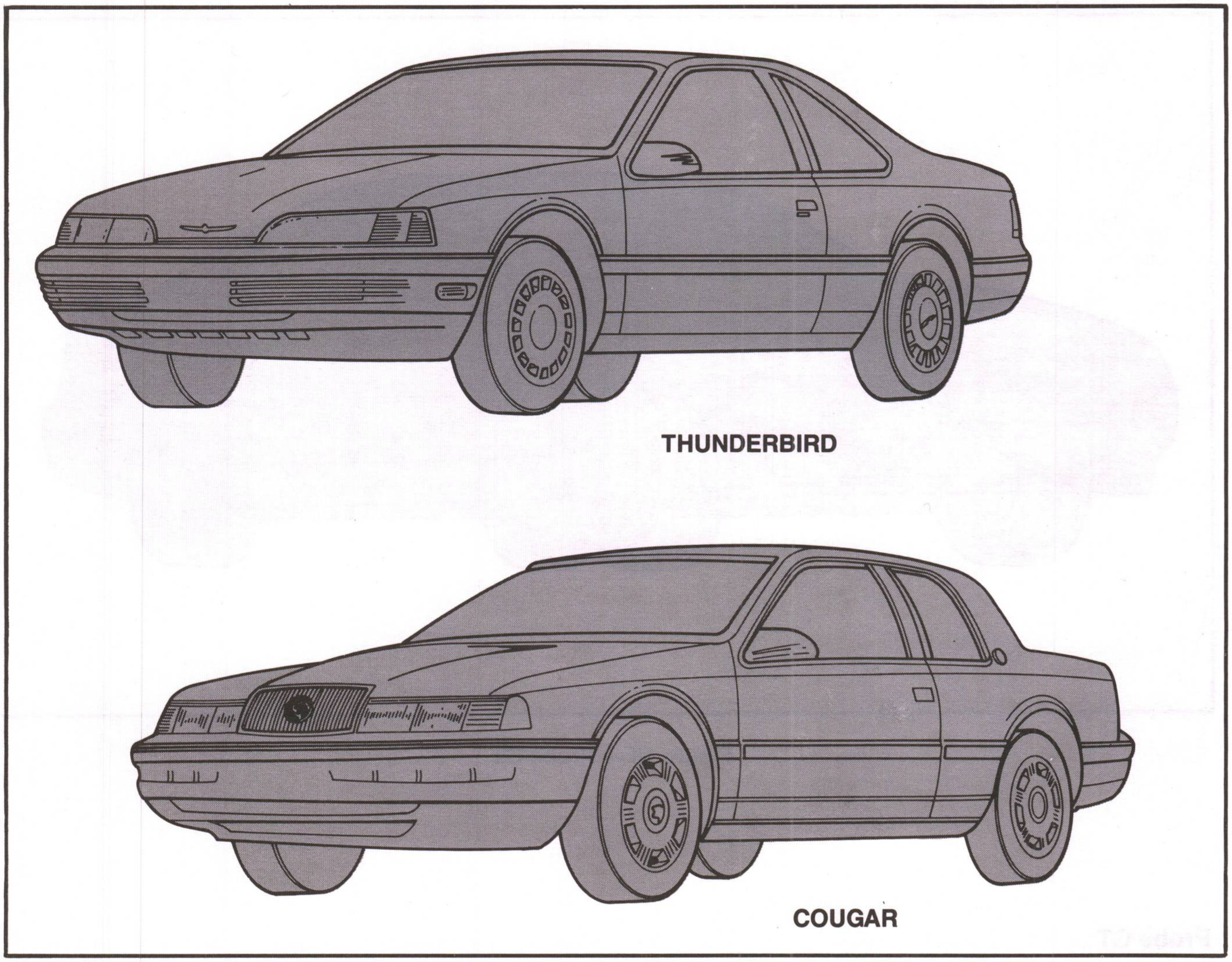


Figure 19 — Thunderbird/Cougar

Thunderbird/Cougar

In this application (Fig. 19) the following points should be remembered:

- **The actuating device is mounted on the power steering pump.**
- **Steering assist is varied by changing the orifice size within the EVO actuator.**
- **Steering assist is based on vehicle speed and steering wheel rotation.**

STEERING SYSTEM DIAGNOSTICS

This section details the steps and procedures required to properly diagnose malfunctions within the electronic steering system. In addition, special tools, diagnostic tool attachment and connector locations will be highlighted.

Typical Conditions To Look For

Electronic steering systems do not often fail or perform improperly. If there is a malfunction that occurs, it will typically be noticed by a change in steering effort, such as a customer comment that the system provides full assist even at higher speeds or that assist is not consistent.

Instances of a complete failure of the power steering system where there is no assist provided are not usually electronically related. This is because the electronic portions of the power steering systems are designed to provide full assist in the event of a component failure or system malfunction. In the event of a complete failure, make sure that the mechanical portions of the system are in good condition and there is adequate fluid in the reservoir before suspecting the electronic portion of the steering system.

Another important point to note is that each of the electronic steering systems can be easily self tested to pinpoint specific malfunctions or failed components/circuits.

Continental Variable Assist Power Steering System Diagnostics

Self-Test on the Continental Variable Assist Power Steering System is accomplished at the diagnostic connector located in the engine compartment near the brake fluid reservoir and brake booster (Fig. 20). The system is self-tested using digital and analog volt-ohm meters.

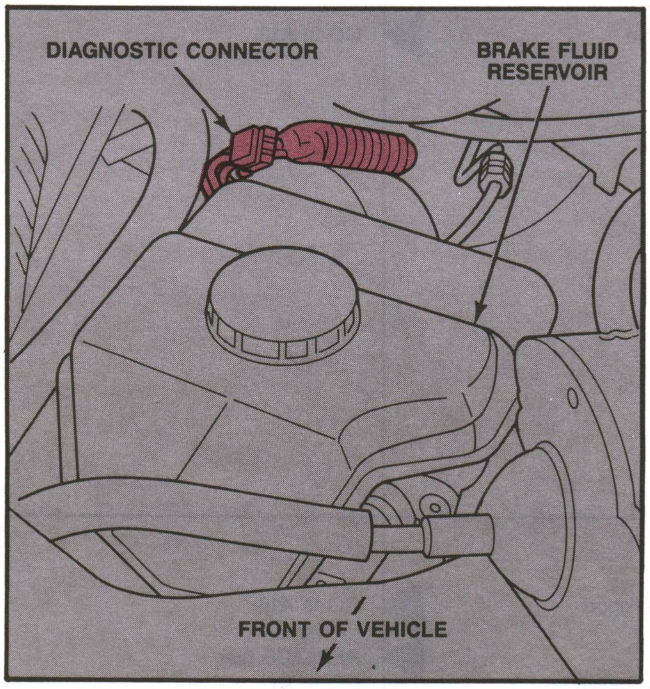
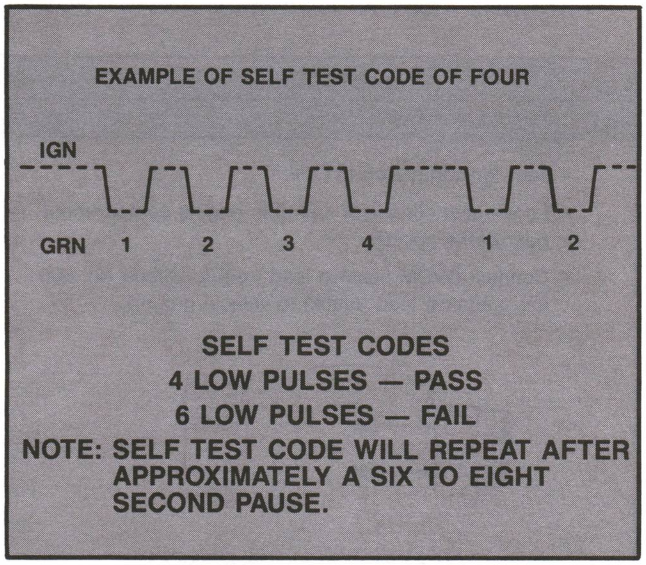


Figure 20 — Continental Diagnostic Connector

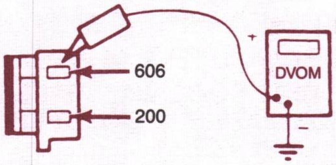
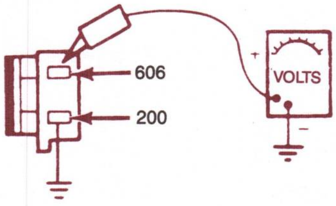


SELF TEST CODES
4 LOW PULSES — PASS
6 LOW PULSES — FAIL
NOTE: SELF TEST CODE WILL REPEAT AFTER APPROXIMATELY A SIX TO EIGHT SECOND PAUSE.

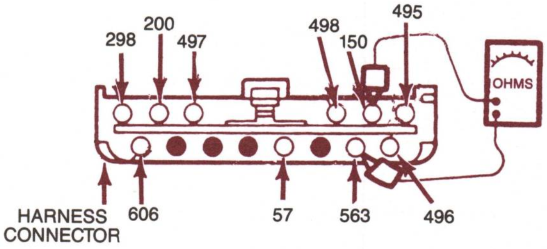
Figure 21 — Code Pattern (Voltmeter Sweeps)

The test has two parts and provides diagnostic information by pulsing the voltmeter (Fig. 21).

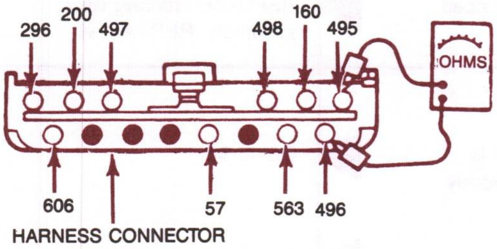
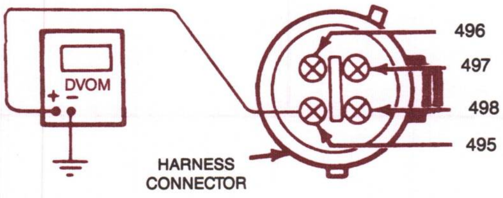
PINPOINT TEST A: VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS

TEST STEP	RESULT		ACTION TO TAKE
A1 MODULE CHECK			
- Turn ignition switch to OFF. - Locate test connector 14489 in engine compartment near brake booster - Connect DVOM positive lead (red) to Circuit No. 606 and negative lead (black) to vehicle ground.  - Position DVOM where it can be observed. - Start engine. - Observe voltage reading on DVOM.	Voltage reads 11V-14V		GO to **A2**.
	Voltage reads zero		GO to **A3**.
A2 MODULE CHECK	**Efforts Change?**	**Number of Sweeps**	
- Turn ignition switch to OFF. - Connect an Analog voltmeter as in Step A1. - Use jumper wire and ground Circuit No. 200.  - Start engine. - Rotate steering wheel for approximately 90 seconds noting any changes in steering effort. The effort required to turn the steering wheel should vary between light and heavy in both directions. - After approximately 90 seconds, voltmeter will show a sweep pattern four times between battery voltage and zero if module proveout is OK. Six or zero sweeps if a system component is malfunctioning. After a five second pause, the sweep pattern will be repeated.	Yes	4	GO to **A4**.
	No	0	GO to **A12**.
	No	4	GO to **A7**.
	No	6	GO to **A12**.
A3 FUSE CHECK			
- Inspect fuse located in fuse panel on LH side below instrument panel.	Fuse good		GO to **A16**.
	Fuse blown		REPLACE fuse. GO to **A1**.

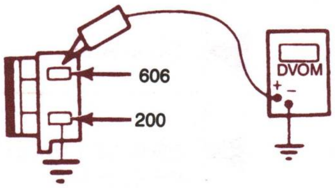
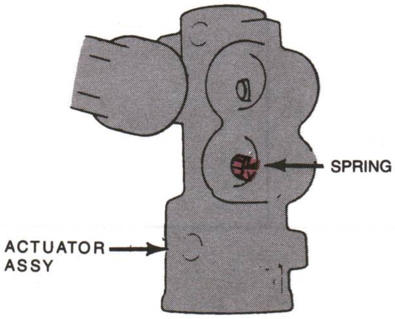
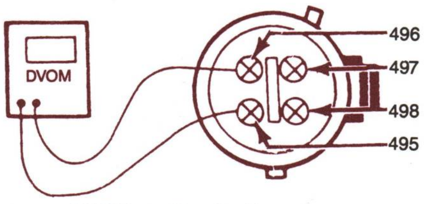
PINPOINT TEST A: VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

TEST STEP	RESULT	ACTION TO TAKE
A4 TEST DRIVE VEHICLE		
• Ensure VAPS system is connected. • Drive vehicle up to 55 M.P.H. • Do steering efforts change and is effort balanced (left vs. right turn direction). • While driving vehicle, note operation of speedometer	Change in steering effort ▶	Diagnostics complete system is OK.
	No change in steering effort ▶	GO to **A5**.
	Efforts unbalanced left to right ▶	REPLACE steering gear assembly. REPEAT **A4**.
A5 SPEEDOMETER CHECK		
• Note operation of speedometer (from Step A4). The VAPS system requires a speed signal from the vehicle speed sensor. If the speedometer or speed control does not work, these systems should be serviced using the appropriate diagnostic and service procedures.	Speedometer is operating properly ▶	GO to **A6**.
	Speedometer does not operate properly ▶	REPAIR as required. GO to **A4**.
A6 SPEED SENSOR CIRCUIT CHECK		
• Disconnect VAPS connector from module • Connnecct DVOM across Circuits No. 150 and No. 563. • Measure resistance  298 200 497 498 150 495 OHMS HARNESS CONNECTOR 606 57 563 496	Resistance is between 150-225 ohms. ▶	REPLACE VAPS module. GO to **A4**.
	Resistance is less than 150 or greater than 225 ohms. ▶	SERVICE harness. GO to **A4**.

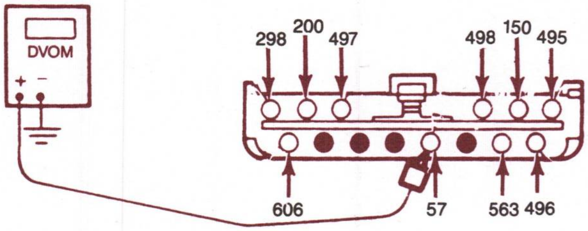
PINPOINT TEST A VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

TEST STEP	RESULT	ACTION TO TAKE
A7 MODULE CHECK		
• Turn ignition switch to OFF. • Disconnect VAPS harness connector from module. • Connect DVOM to Circuits No. 495 and No. 496. • Measure resistance.  296 200 497 498 160 495 OHMS 606 57 563 496 HARNESS CONNECTOR • Connect DVOM to Circuits No. 497 and 498. • Measure resistance.	Resistance between 43 and 70 ohms ▶	GO to **A8**.
	Resistance less than 43 04 greater than 70 ▶	GO to **A10**.
A8 HARNESS VOLTAGE AT ACTUATOR CONNECTOR		
• Turn ignition switch to OFF. • Verify that VAPS connector is connected to VAPS module. • Disconnect actuator connector from VAPS harness connector. • Turn ignition switch to RUN. • Wait five seconds. • Measure D.C. voltage between Circuit No. 495 and ground. Then measure voltage between Circuit No. 496 and ground. • One of these two circuits should be greater than 10 volts and the other less than 2 volts. • Repeat the two steps above for Circuit No. 497 and 498.  DVOM + − 496 497 498 495 HARNESS CONNECTOR	Voltage check OK ▶	GO to **A9**.
	One or more voltage readings not as specified ▶	REPLACE VAPS module. GO to **A2**.

PINPOINT TEST A VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

TEST STEP	RESULT	ACTION TO TAKE
A9 ACTUATOR (MECHANICAL) CHECK		
• Turn ignition switch to OFF. • Remove actuator. Refer to removal procedure in this section • Reconnect actuator connector to VAPS harness connector • Attach DVOM to diagnostic connector (near brake booster) as shown.  • Turn ignition switch to ON. • The module will go through a diagnostic check, consisting initially of the 90 second efforts change sequence. • If the actuator is mechanically operable, the actuator valve will move between its two limits of travel. This movement can be detected by watching the valve spring expand and relax between the travel limits. 	Spring moves	REPLACE steering gear assembly. GO to **A2**.
	Spring does not move	REPLACE ACTUATOR. GO to **A2**.
A10 ACTUATOR (ELECTRICAL) CHECK		
• Turn ignition switch to OFF. • Disconnect actuator connector from harness connector. • Connect DVOM to Circuits No. 495 and No. 496. • Measure resistance.  • Connect DVOM to Circuits No. 497 and No. 498 • Measure resistance.	Resistance between 43 and 70 ohms.	GO to **A11**.
	Resistance less than 43 or greater than 70 ohms	REPLACE actuator. GO to **A2**.

PINPOINT TEST A VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

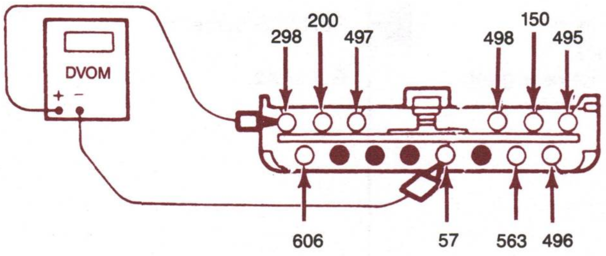
TEST STEP	RESULT	ACTION TO TAKE
A11 CONTINNUITY CHECK		
- Turn ignition switch to OFF. - Disconnect module connector from module. - Check continuity of Circuit 495 from module connector to actuator connector. - Repeat for Circuits 496, 497 and 498.	All circuits check OK.	GO to **A9**.
	Circuit fails continuity check	SERVICE harness. Go to **A2**.
A12 VAPS HARNESS AND CONNECTORS CHECK		
- Turn ignition switch to OFF. - Disconnect VAPS connector from module. - Connect positive lead of DVOM to Circuit No. 57 and negative lead to ground - Measure resistance.  DVOM + − 298 200 497 498 150 495 606 57 563 496	Resistance between 0 and 15 ohms	GO to **A13**.
	Resistance greater than 15 ohms	SERVICE harness. REPEAT **A12**.
	NOTE: all doors and hood must be closed for proper resistance readings	

PINPOINT TEST A VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

TEST STEP	RESULT	ACTION TO TAKE
A13 VAPS HARNESS AND CONNECTORS CHECK		
	Voltage readings near given values	GO to **A14**.
	One or more resistance values not near given values	SERVICE harness. Repeat to **A13.**

A13 VAPS HARNESS AND CONNECTORS CHECK

- Disconnect VAPS connector from module.
- Connect DVOM as shown.



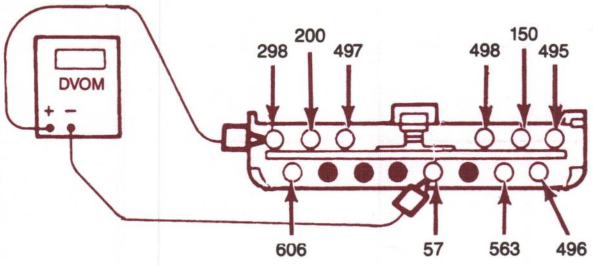
- Turn ignition switch to ON.
- Measure voltage at each circuit, (Circuit No. 57 to ground).

Row	Circuit No.	Function	Volts (DC)
Top	298	Power	Battery
Top	200	Diagnostic	<.1
Top	497	Actuator	<.1
Top	498	Actuator	<.1
Top	150	Speed Sensor	—
Top	495	Actuator	<.1
Bottom	606	Diagnostic	<.1
Bottom	57	Ground	<.1
Bottom	563	Speed Sensor	—
Bottom	496	Actuator	<.1

PINPOINT TEST A VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

A14 ACTUATOR (MECHANICAL) CHECK

- Turn ignition switch to OFF.
- Measure resistance between Circuit No. 57 ground and all other indicated circuits.
- Connect DVOM as shown



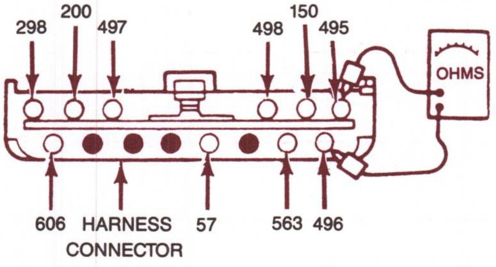
- Measure resistance of each circuit, by moving positive lead.

Row	Circuit No.	Function	Typical Value ( )
Top	298	Power	3.6
Top	200	Diagnostic	Open
Top	497	Actuator	Open
Top	498	Actuator	Open
Top	150	Speed Sensor	195
Top	495	Actuator	Open
Bottom	606	Diagnostic	Open
Bottom	563	Speed Sensor	0.6
Bottom	496	Actuator	Open

RESULT	ACTION TO TAKE
Resistance values near given value ▶	GO to **A15**.
One or more resistance values not near given values ▶	SERVICE harness. GO to **A2**.

A15 ACTUATOR (ELECTRICAL) CHECK

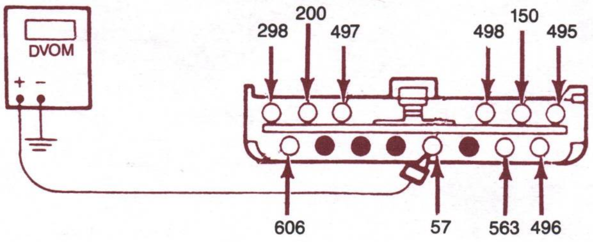
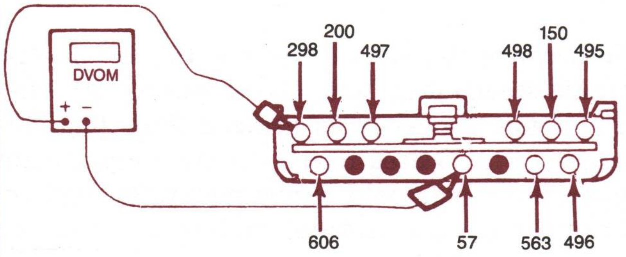
- Connect VOM to Circuits No. 495 and No. 496
- Measure resistance



- Connect VOM to Circuits No. 497 and 498.
- Measure resistance.

RESULT	ACTION TO TAKE
Resistance between 43 and 70 ohms ▶	REPLACE VAPS module. GO to **A2**.
Resistance less than 43 or greater than 70 ohms ▶	SERVICE harness or connectors GO to **A2**.

PINPOINT TEST A VARIABLE ASSIST POWER STEERING ELECTRICAL COMPONENT DIAGNOSIS - Continued

TEST STEP	RESULT	ACTION TO TAKE
A16 VAPS HARNESS AND CONNECTORS CHECK		
- Turn ignition switch to OFF. - Disconnect VAPS connector from module. - Connect positive lead of DVOM to Circuit No. 57 and negative lead to ground. - Measure resistance.  DVOM + – 298 200 497 498 150 495 606 57 563 496	Resistance between 0 and 15 ohms	GO to **A17**.
	Resistance greater than 15 ohms	SERVICE harness. GO to **A1**.
	NOTE: All doors and hood must be closed for proper resistance readings.	
A17 VAPS HARNESS AND CONNECTORS CHECK		
- Connect positive lead of DVOM to Circuit No. 298 and negative lead to Circuit No. 57. - Turn ignition switch to ON. - Measure voltage - Turn ignition switch to OFF.  DVOM + – 298 200 497 498 150 495 606 57 563 496	12 V	GO to **A18**.
	0 volt	Service harness. GO to **A1**.
A18 CONTINUITY CHECK		
- Check continuity of Circuit No. 606 from diagnostic	Circuit No. 606 is OK	REPLACE module. GO to **A1**.
	Circuit No. 606 is BAD	SERVICE Circuit No. 606. GO to **A1**.

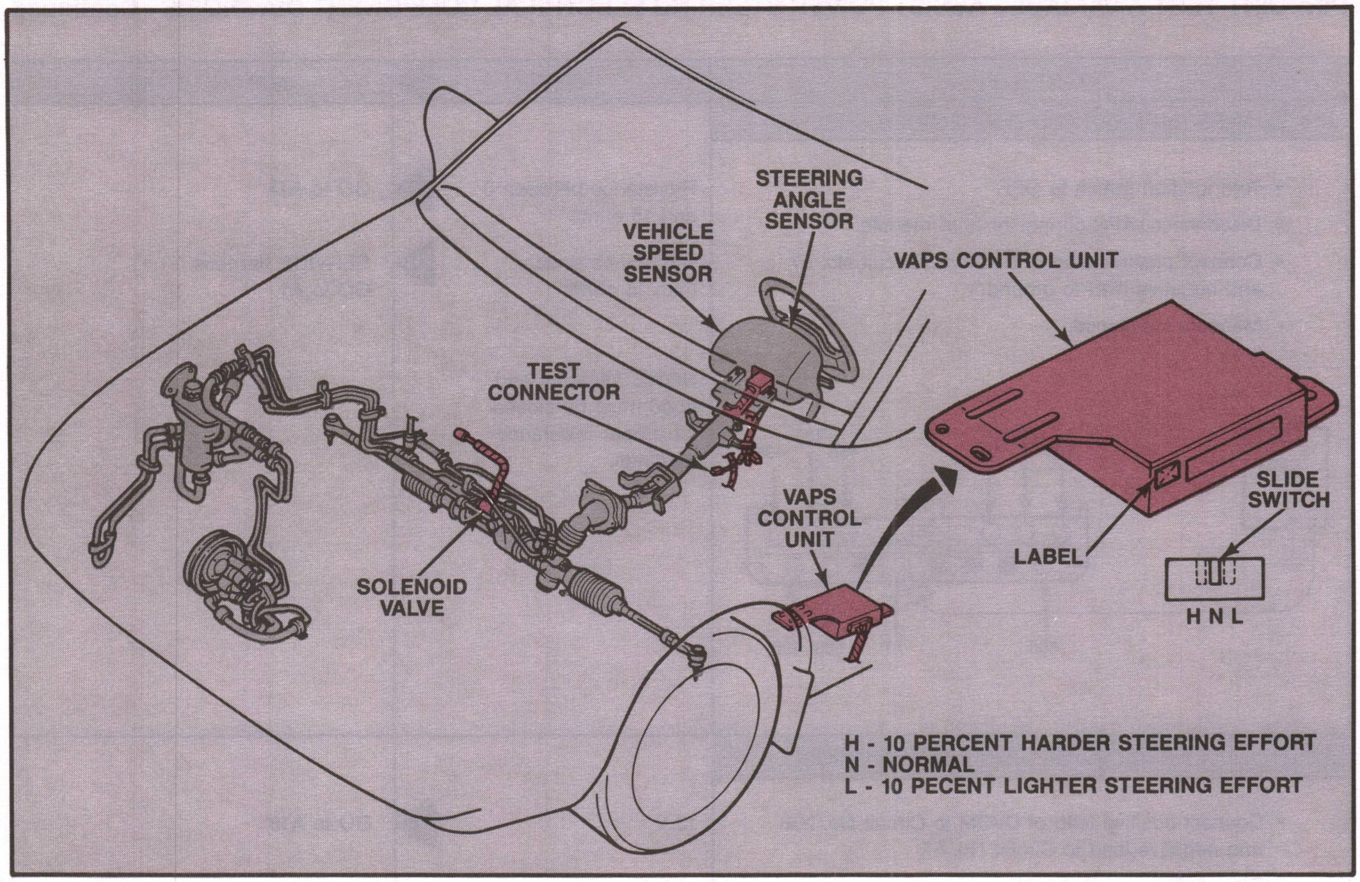

STEERING ANGLE SENSOR
VEHICLE SPEED SENSOR
VAPS CONTROL UNIT
TEST CONNECTOR
VAPS CONTROL UNIT
SLIDE SWITCH
LABEL
SOLENOID VALVE
H N L
H - 10 PERCENT HARDER STEERING EFFORT
N - NORMAL
L - 10 PECENT LIGHTER STEERING EFFORT

Figure 22 — Probe GT Electronic Steering Module

Probe GT Variable Assist Power Steering System Diagnostic Procedures

The self-test procedure on the Probe GT is fairly complicated in that there are three separate portions to the test. Prior to performing any diagnostics on the steering system it is important to note a switch setting on the electronic steering module (Fig. 22).

The switch has three settings H for hard, N for normal and L for light. The H setting makes steering effort approximately 10% higher than the normal setting, whereas the L setting makes the steering effort about 10% lighter than normal. Check the switch setting before attempting repairs or diagnosis because the customer complaint may be remedied by providing a different steering feel.

To perform the self-test on the Probe GT electronic steering system, the electronic steering diagnostic connector is utilized (Fig. 23). This connector is located in the engine compartment near the windshield wiper motor. To perform diagnostics an analog voltmeter must be attached to the connector. The positive lead goes to the yellow/black wire terminal and the negative lead goes to the black wire terminal.

NOTE: The diagnostic connector is also used for performing the self-test on the electronic suspension system. That is what the blue/white wire is for. The voltmeter must be properly hooked up on the connector to receive the correct code readout.

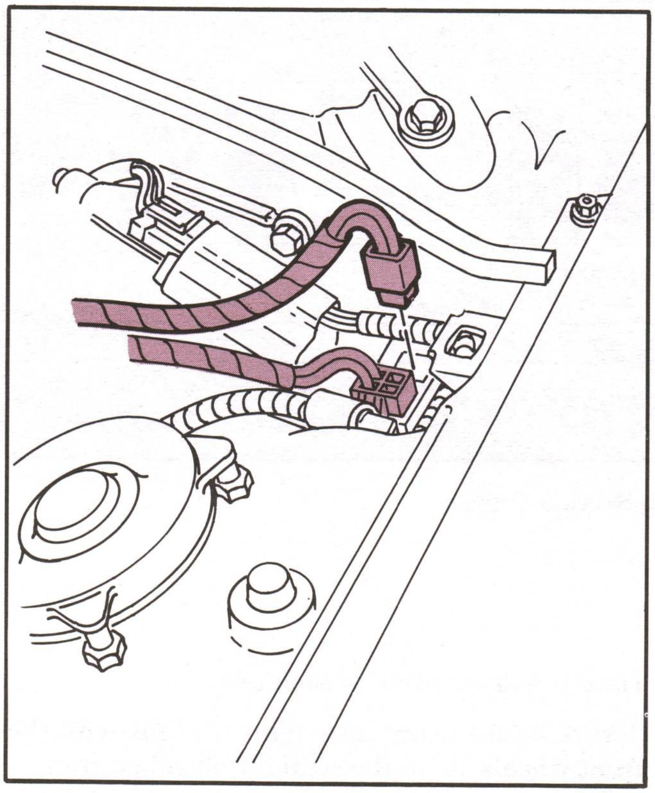


Figure 23 — Diagnostic Connector

The three tests that make up the self-test are designed to test the system under different operating conditions. Here are the steps that are involved in testing the system.

Visual Inspection and Vehicle Preparation: Before attaching the test equipment, visually inspect the vehicle for abnormal conditions such as loose wires, improper connections, or damaged hoses. Make any necessary repairs before continuing with the self-test.

Equipment Attachment: An analog volt-ohmmeter (VOM) can be used to read variable assist power steering service codes (Fig. 24). Use the following instructions to attach the VOM:

1. Turn the ignition on.
2. Set the VOM on a DC voltage range to read from 0 — 15 volts.
3. Using the VOM, connect the red lead (+) to the yellow/black terminal and the black lead (-) to the black wire terminal of the suspension test connector.

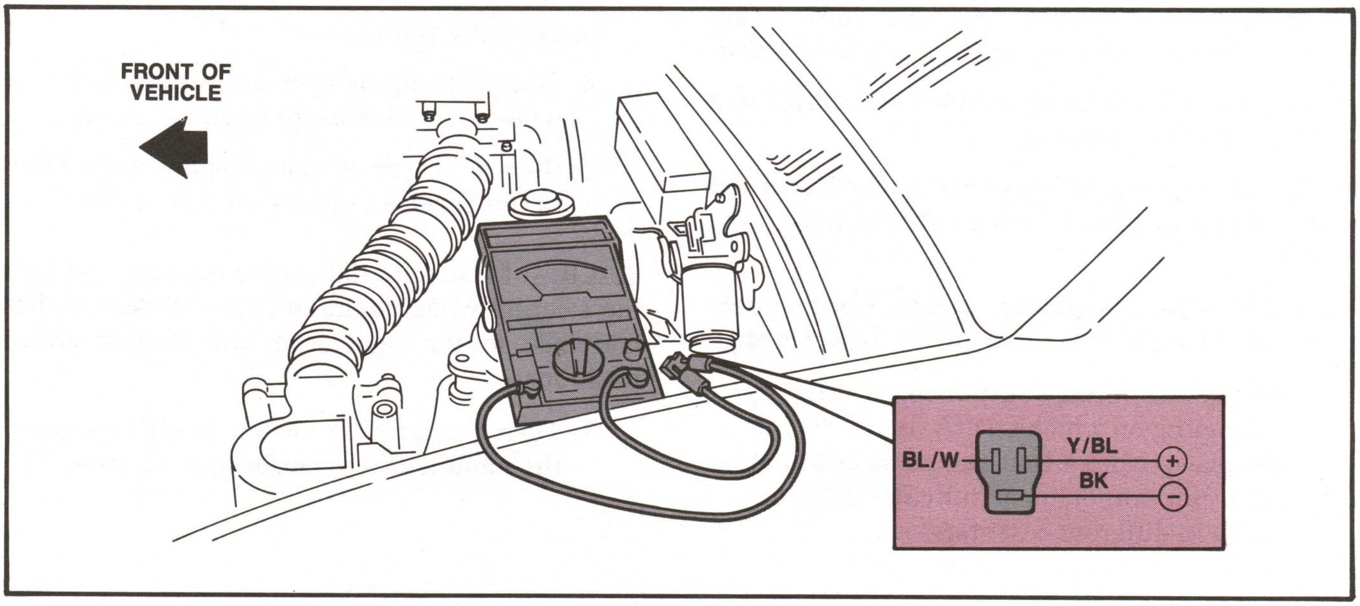


Figure 24 — Equipment Attachment

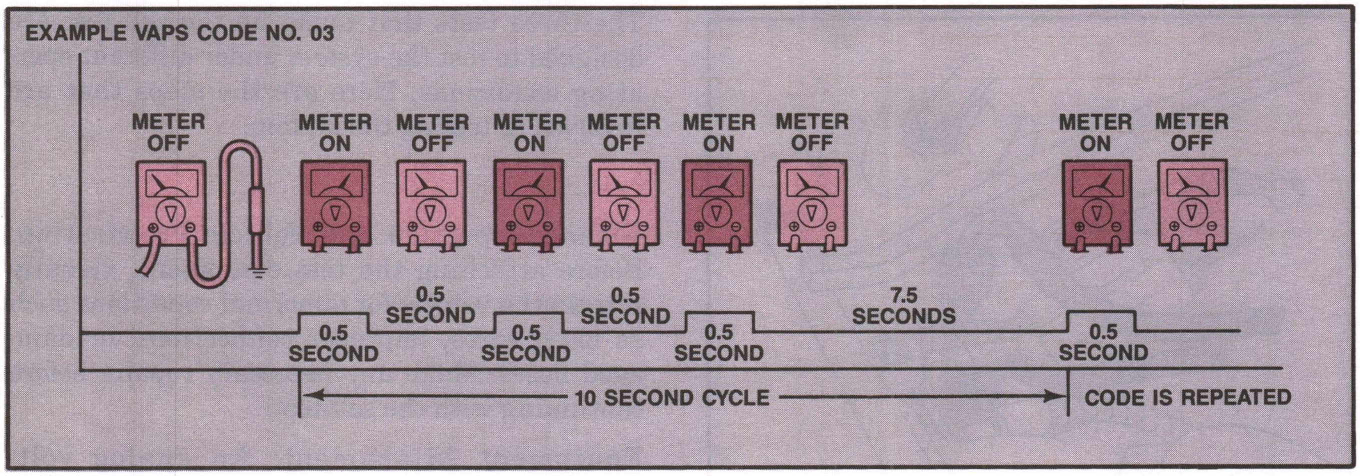

EXAMPLE VAPS CODE NO. 03
METER OFF
METER ON
METER OFF
METER ON
METER OFF
METER ON
METER OFF
METER ON
METER OFF
0.5 SECOND
0.5 SECOND
0.5 SECOND
0.5 SECOND
0.5 SECOND
7.5 SECONDS
0.5 SECOND
0.5 SECOND
10 SECOND CYCLE
CODE IS REPEATED

Figure 25 — Reading Service Codes

Reading Service Codes

The individual service codes for steering system diagnosis are represented by a pulsing or sweeping movement of an analog voltmeter's needle across the voltmeter face. An example of needle movement is shown in Figure 25.

Key ON Engine Running Quick-Test

There are three different test procedures to follow for the Key ON Engine Running Quick-Test.

- **Test A — Engine idling with the wheels set in a straight ahead position.**
- **Test B — Engine idling with the wheels turned at a 45 degree angle to the left and then to the right.**
- **Test C — Vehicle jacked up with front wheels being driven at more than 10 km/h (6.2 mph).**

> **NOTE:** The voltage output codes will vary depending on which test (A, B or C) is taking place. Notice that the same code pattern can sometimes indicate different faults in different test steps.

Here is a description of each test.

Test A — Make sure the engine is idling with the front wheels set in the straight ahead position.

1. Turn the ignition switch to OFF to reset the control module before performing the test.
2. Attach the test equipment according to the prior instructions.
3. Turn the volt-ohmmeter ON.
4. Start the engine and run at idle with the wheels in the straight ahead position.
5. Record all service codes displayed and refer to the Service Code Chart A (Fig. 26).

Test B — Make sure the engine is idling and turn the steering wheel approximately 45 degrees left and then to the right from the straight ahead position.

1. Turn the ignition switch to OFF to reset the module before performing the test.

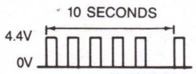
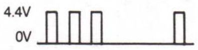
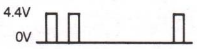
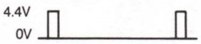
TEST STEP	CODE PATTERN	ACTION TO TAKE
A (Set steering wheel in straight ahead position with engine idling.)	05 	Go to Pinpoint Test A
	03 	Go to Pinpoint Test B
	02 	Go to Pinpoint Test C
	01 	Press Code
	00	Go to Pinpoint Test Q

Figure 26 — Test A Procedures

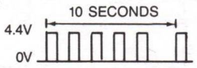
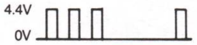
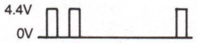
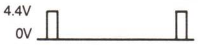
TEST STEP	CODE PATTERN	ACTION TO TAKE
B (Turn the steering wheel 45 degrees left and right from center with engine idling.)	05 	Go to Pinpoint Test A
	03 	Go to Pinpoint Test B
	02 	Press Code
	01 	Go to Pinpoint Test C
	00	Go to Pinpoint Test Q

Figure 27 — Test B Procedures

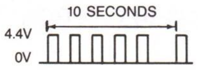
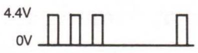
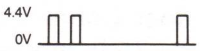
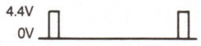
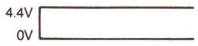
TEST STEP	CODE PATTERN	ACTION TO TAKE
C (Jack up the vehicle and drive the front wheels at more than 10 km/h (6.2 mph).	05 	Go to Pinpoint Test A
	03 	Go to Pinpoint Test B
	02 	Go to Pinpoint Test C
		Go to Pinpoint Test D
	ON 	Go to Pinpoint Test C If fault is not found within steering angle sensor or circuit, Do Not proceed to Pinpoint Test Q as directed in STEP C7. Go to Steering Service Section 13-01.
	00	Go To Pinpoint Test Q

Figure 28 — Test C Procedures

2. Start the engine and run at idle, turn the steering wheel 45 degrees left then to the right from center.
3. Record all service codes and refer to Service Code Chart B (Fig. 27)

Test C — For this test the vehicle must be jacked up and the front wheels driven at more than 10 km/h (6.2 mph).

1. Turn the ignition switch to OFF to reset the control module before performing the test.
2. Place the vehicle on jack stands or other suitable vehicle lifting device.

NOTE: Front suspension must be supported so that wheels do not hang down. Failure to provide support to the front suspension could cause damage to the constant velocity (CV) joints.

3. Start the engine and drive the front wheels at more than 10 km/h (6.2 mph).
4. Record all service codes and refer to the Service Code Chart C (Fig. 28)

NOTE: The ABS warning light may come on. This is not a failure. The light will go off when the ignition switch is turned OFF and back ON.

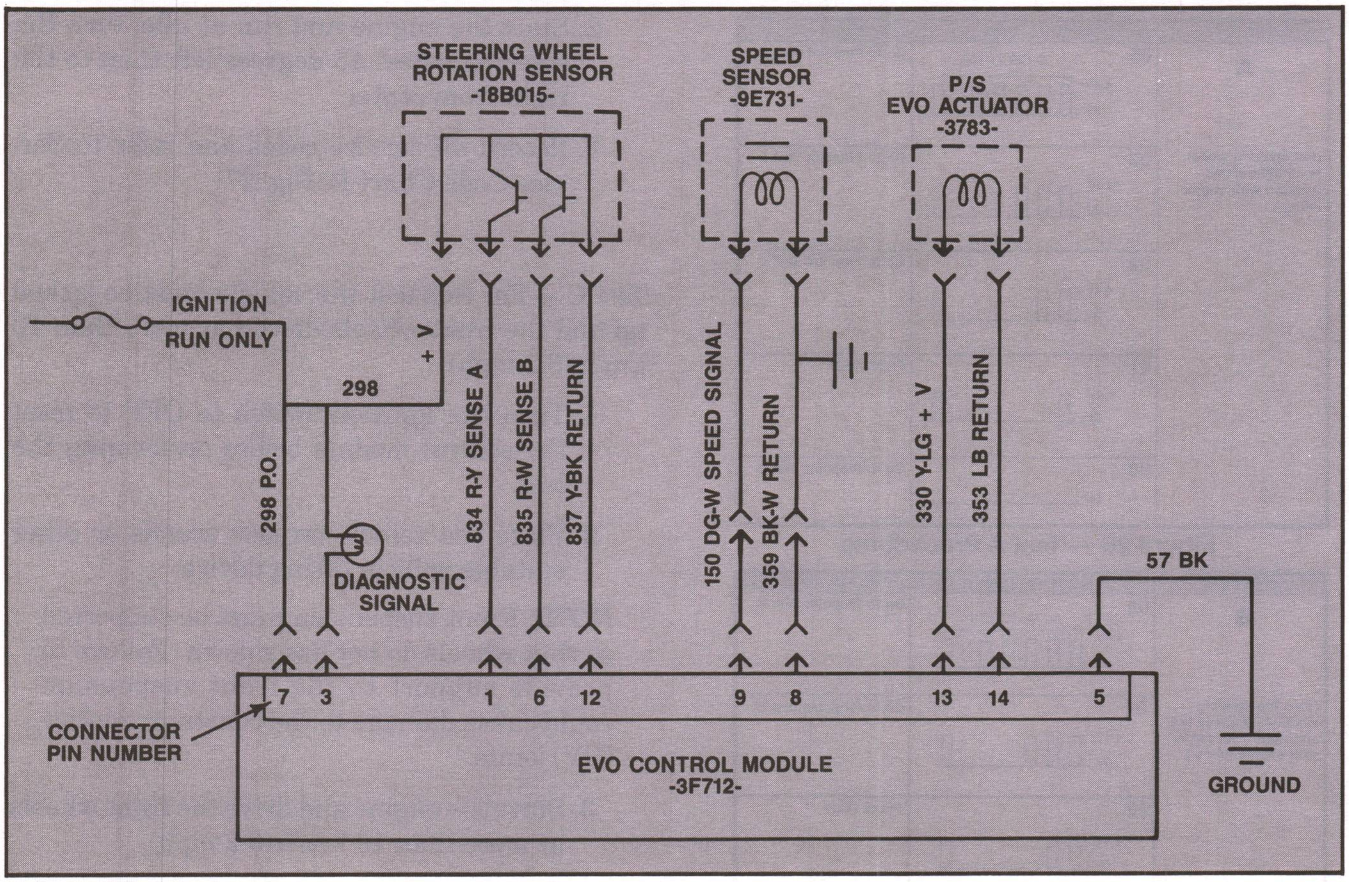

STEERING WHEEL
ROTATION SENSOR
-18B015-
SPEED
SENSOR
-9E731-
P/S
EVO ACTUATOR
-3783-
IGNITION
RUN ONLY
298
+ V
834 R-Y SENSE A
835 R-W SENSE B
837 Y-BK RETURN
150 DG-W SPEED SIGNAL
359 BK-W RETURN
330 Y-LG + V
353 LB RETURN
298 P.O.
DIAGNOSTIC
SIGNAL
57 BK
7
3
1
6
12
9
8
13
14
5
CONNECTOR
PIN NUMBER
EVO CONTROL MODULE
-3F712-
GROUND

Figure 29 — EVO Controller Sensor Circuit

Thunderbird/Cougar EVO Power Steering System Diagnostic Procedures

There are several characteristics of the EVO steering system that should be kept in mind when diagnosing possible malfunctions. They include:

- **The EVO system is designed to return to full assist during high speed evasive maneuvers.**
- **The EVO system is designed with a fail safe feature to allow full assist in the event of an EVO electrical circuit malfunction.**
- **Service diagnostics are designed into the control module to assist in troubleshooting the system.**
- **The EVO system is combined with the Automatic Ride Control (ARC) system in the Super Coupe and XR7 models.**

Note that in the Thunderbird LX and Cougar LS, there is a specific EVO control module. This module is positioned inside the module tray, located in the luggage compartment on the LX and LS models.

On the Super Coupe and XR7 the EVO and ARC functions are programmed into a single module. This has an effect on diagnostics because a STAR Tester or Super STAR II Tester is used in diagnostics on the Super Coupe and XR7 EVO and ARC systems. Note that this is the only current electronic steering system on which the STAR Tester or similar tool is utilized. On the Thunderbird LX and Cougar LS, diagnostics are performed using the EVO Service Diagnostic Lamp.

Because ARC is not offered on the Thunderbird LX and Cougar LS, there is a separate diagnostic method.

Thunderbird LX/Cougar LS Diagnostics

The following components of the EVO system can be checked for proper operation using the EVO Service Diagnostic Lamp.

- **EVO Control Module**
- **Steering Wheel Rotation Sensor**
- **Speed Sensor**
- **EVO Actuator**

This procedure is a systematic method of determining which of the above components, if any, require service. The EVO Control Module contains a lamp driver circuit used to flash diagnostic information for service (Fig. 29). This open collector circuit will send current (typical operating current is approximately 350 mA; surge current 5.0 A for 40 milliseconds maximum) to a warning lamp to indicate a possible problem. The output is short circuit protected to avoid damage to the controller. If a short exists, the controller will not attempt to turn the lamp on until power is removed from the controller and then reapplied. This information will be transmitted during normal operation of the vehicle and does not require the system to be put into a special mode.
special mode.

The controller is able to determine if there is a defect in the steering wheel sensor signal, vehicle speed sensor signal, or the actuator output circuit, and take appropriate action.

Wiring number and color assignments are as follows (Fig. 30).

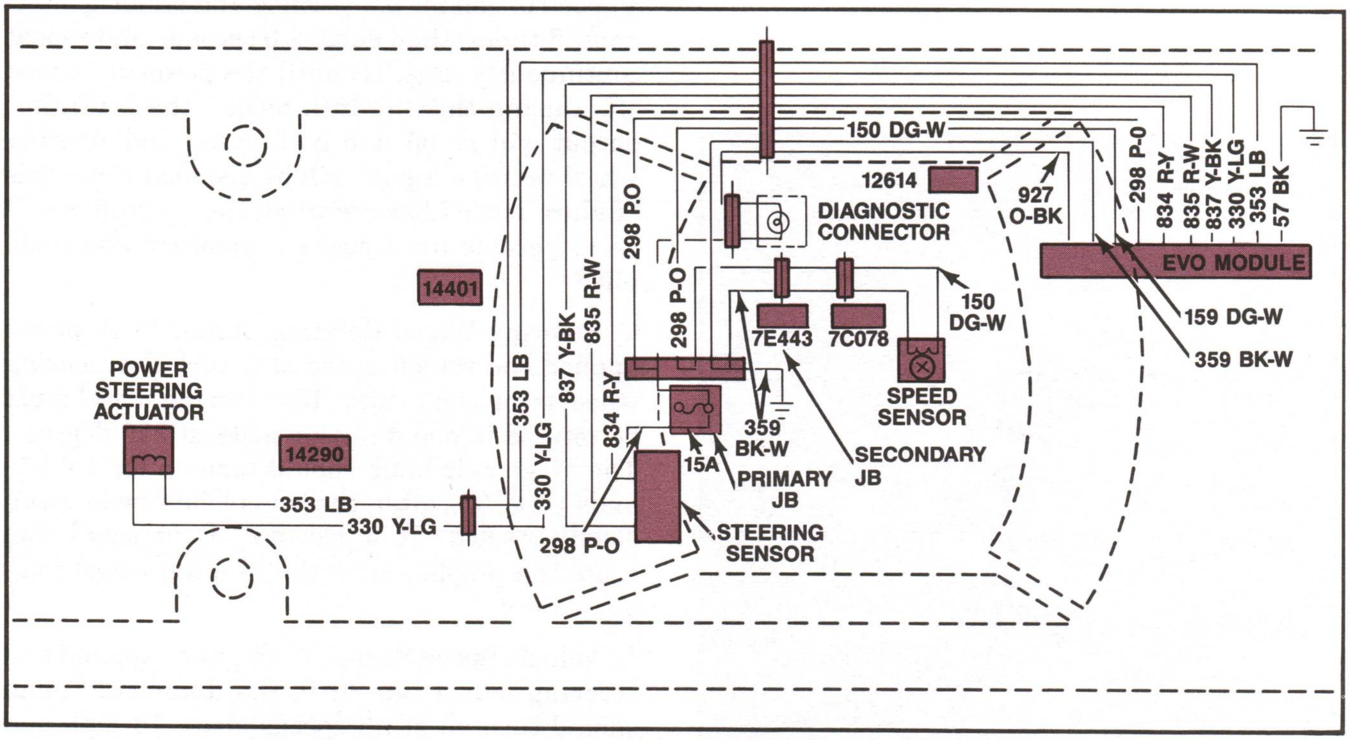

150 DG-W
12614
DIAGNOSTIC CONNECTOR
927 O-BK
298 P-O
834 R-Y
835 R-W
837 Y-BK
330 Y-LG
353 LB
57 BK
EVO MODULE
159 DG-W
359 BK-W
150 DG-W
7E443
7C078
SPEED SENSOR
SECONDARY JB
359 BK-W
15A
PRIMARY JB
STEERING SENSOR
298 P-O
298 P.O
298 P-O
835 R-W
837 Y-BK
834 R-Y
353 LB
330 Y-LG
14401
14290
POWER STEERING ACTUATOR
353 LB
330 Y-LG

Figure 30 — Wiring Number and Color Assignments

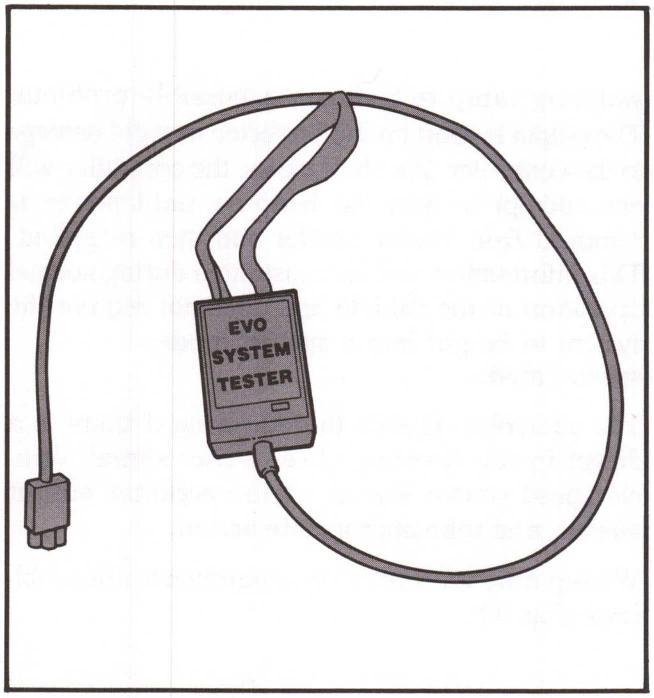


Figure 31 — Rotunda EVO System Tester

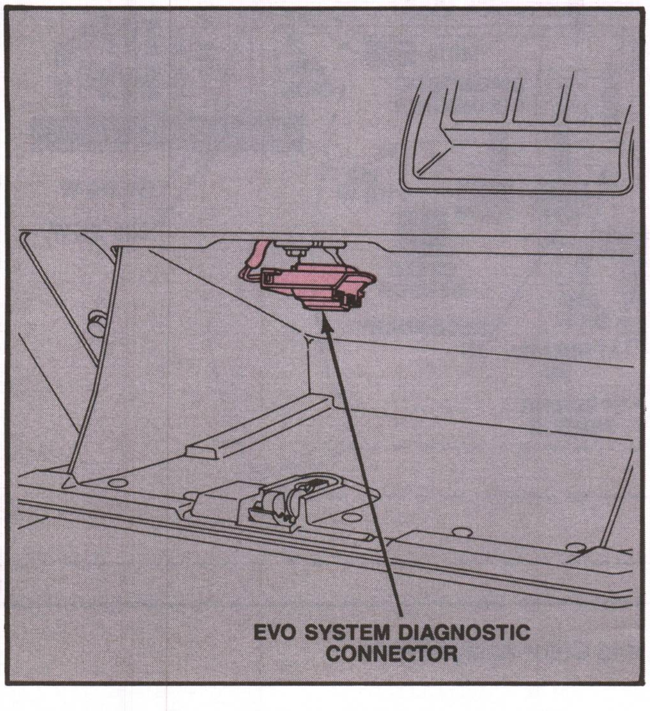


Figure 32 — EVO System Tester Installed

This procedure is a systematic method of determining which of the above components, if any, require servicing. The diagnostic procedure requires the use of a Service Diagnostic Lamp. The diagnostic lamp is available through Rotunda (105-00007) (Fig. 31). A point to note about this device is that it is not part of the Dealer Special Tool Package and must be purchased separately. To diagnose the system the EVO System Tester must be attached to the diagnostic connector located above the glove compartment (Fig. 32).

The following bulb signals are possible outputs:

A. Controller Function At power up, the controller will turn on the diagnostic lamp for 1.0 second to indicate a good bulb and that the controller is functional (Fig. 33)

B. Solenoid Actuator Output Circuit After the 1.0 second controller function check, the controller will perform the actuator output test, if there is a short to ground or an open circuit, after the 2.0 seconds delay, the diagnostic lamp will flash a “code 6” (on for 0.5 seconds and off for 0.5 seconds, 6 times) then delay 2.0 seconds and repeat continuously (Fig. 34) until the power is turned off. During this “failure mode” the controller output will be off and both speed and steering wheel rotation inputs will be disabled. Once this “failure mode” has occurred, the controller will be inoperable until power is removed and reapplied.

C. Steering Wheel Rotation Sensor With power applied and vehicle speed at 0, turn the steering wheel from lock to lock. The steering wheel must be rotated in one direction at least 220 degrees. The diagnostic lamp should turn on for 3.0 seconds (Fig. 35) after the wheel has been sufficiently rotated. If it has not, it indicates that there is a problem with the steering wheel rotation sensor.

D. Vehicle Speed Sensor With power applied and steering wheel rate at 0, the diagnostic lamp should turn on at all speeds above 15 mph and turn off when the speed drops below 10 mph (Fig. 36). If the lamp does not function in this manner, then there is a problem with the vehicle speed sensor.

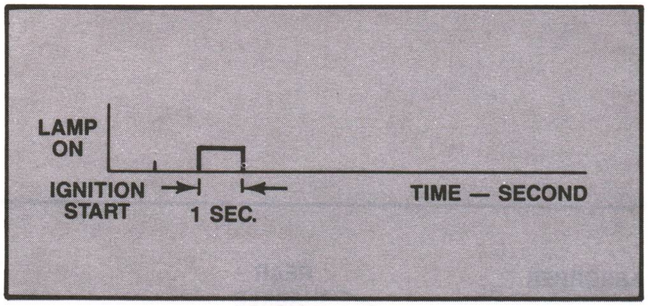


Figure 33 — Controller Function Signal

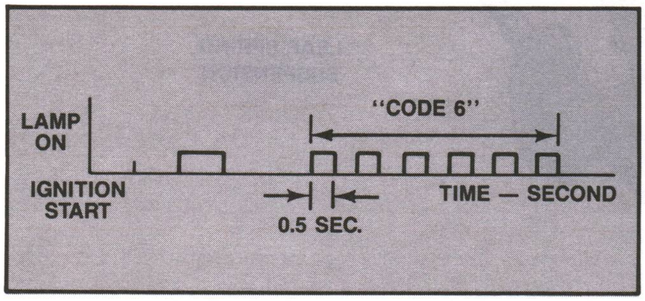


Figure 34 — Solenoid Actuator Output Circuit Failure (Code 6)

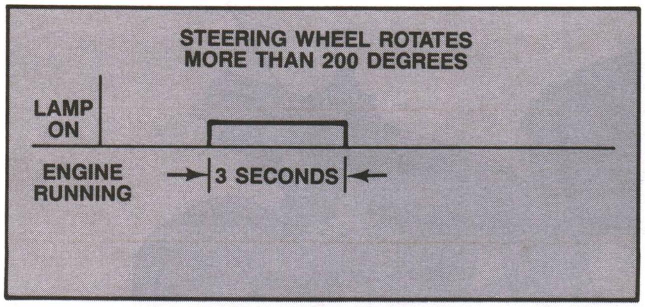


Figure 35 — Steering Wheel Rotation Sensor Signal

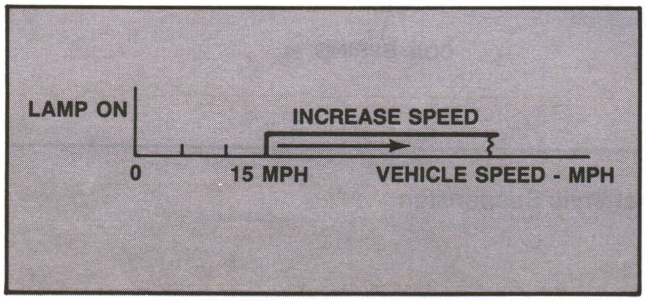


Figure 36 — Vehicle Speed Sensor Signal

For detailed instructions and wiring diagrams related to system diagnostics, refer to the Variable Assist (EVO) Steering System Section for the Thunderbird LX and Cougar LS in the Shop Manual.

Thunderbird Super Coupe and Cougar XR7 Diagnostics

The Thunderbird Super Coupe and the Cougar XR7 do not utilize the stand alone EVO control module. As stated earlier, the EVO and Automatic Ride Control systems are controlled by the Automatic Ride Control module. Diagnostics of the EVO system are covered in the Automatic Ride Control Section of the Shop Manual.

Also, the Service Diagnostic Lamp is not used with these vehicles. Diagnostics are accomplished using the STAR or Super STAR II hand held diagnostic testers. The location of the Automatic Ride Control System diagnostic connector for the Super Coupe and XR7 is under the hood on the passenger side shock absorber tower. For diagnostic information concerning the EVO system on the Super Coupe and XR7, refer to the Automatic Ride Control section of this manual.

ELECTRONIC STEERING CONCLUSION

This completes the steering system portion of this CTP manual. The next section covers Electronic Suspension Systems.

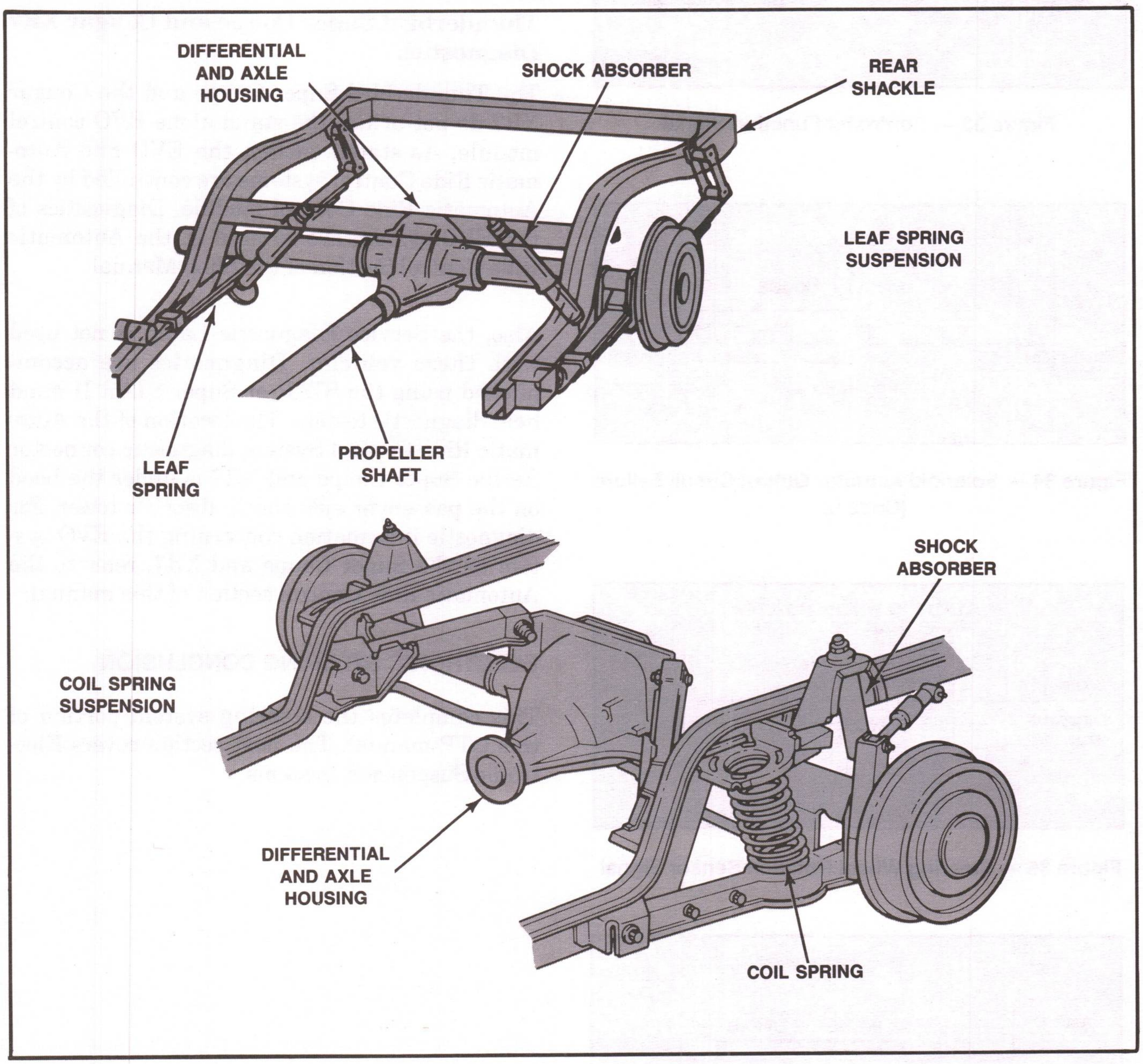

DIFFERENTIAL AND AXLE HOUSING
SHOCK ABSORBER
REAR SHACKLE
LEAF SPRING SUSPENSION
LEAF SPRING
PROPELLER SHAFT
SHOCK ABSORBER
COIL SPRING SUSPENSION
DIFFERENTIAL AND AXLE HOUSING
COIL SPRING

Figure 37 — Conventional Style Suspension

Ford Motor Company has developed several different suspension systems that utilize some form of electronic control. These systems can range from quite simple to complex. Vehicles that utilize electronic suspensions include:

- **Thunderbird Super Coupe and Cougar XR7 — Automatic Ride Control (ARC)**
- **Thunderbird Turbo Coupe (87 & 88) — Programmed Ride Control**
- **Probe GT — Programmed Ride Control**
- **Continental — Air Suspension System**
- **Mark VII and Pre 1988 Continental — Air Suspension System**
- **Crown Victoria, Grand Marquis and Town Car — Rear Load Leveling Suspension**

Each of these systems will be covered in this manual. Prior to reviewing each of these systems let's take a look at basic suspension system operation and the adaptation of electronic control to suspension systems.

BASIC SUSPENSION SYSTEM FUNCTION

There are three basic functions for a suspension system. They are:

1. The suspension system must absorb shock.
2. The suspension system must keep the vehicle level.
3. The suspension system must assist in controlling the vehicle.

Types of Suspensions

There are two basic types of suspension systems to be familiar with that are the basis for all electronically controlled systems. They are the conventional suspension and independent suspension.

Conventional Suspension

The conventional suspension (Fig. 37) utilizes a solid axle and is used on many rear wheel drive vehicles. A conventionally suspended axle typically utilizes a coil spring or leaf spring. These springs are meant to cushion the vehicle from road shocks by allowing the wheel to react and move. Shock absorbers are used in conjunction with the springs to dampen the shock and prevent excessive passenger compartment movement.

Because both of the wheels are attached to a solid axle, road shocks absorbed by one wheel are transferred, to a certain degree, through the entire rear suspension.

Independent Suspension

Independent suspensions are different from the conventional suspension in that shock is absorbed at each individual wheel and is not transferred to the opposite wheel through an axle assembly. Almost all front suspensions produced in the last 30 years have utilized independent suspension for both wheels. Because of its efficiency in absorbing shock, independent sus-

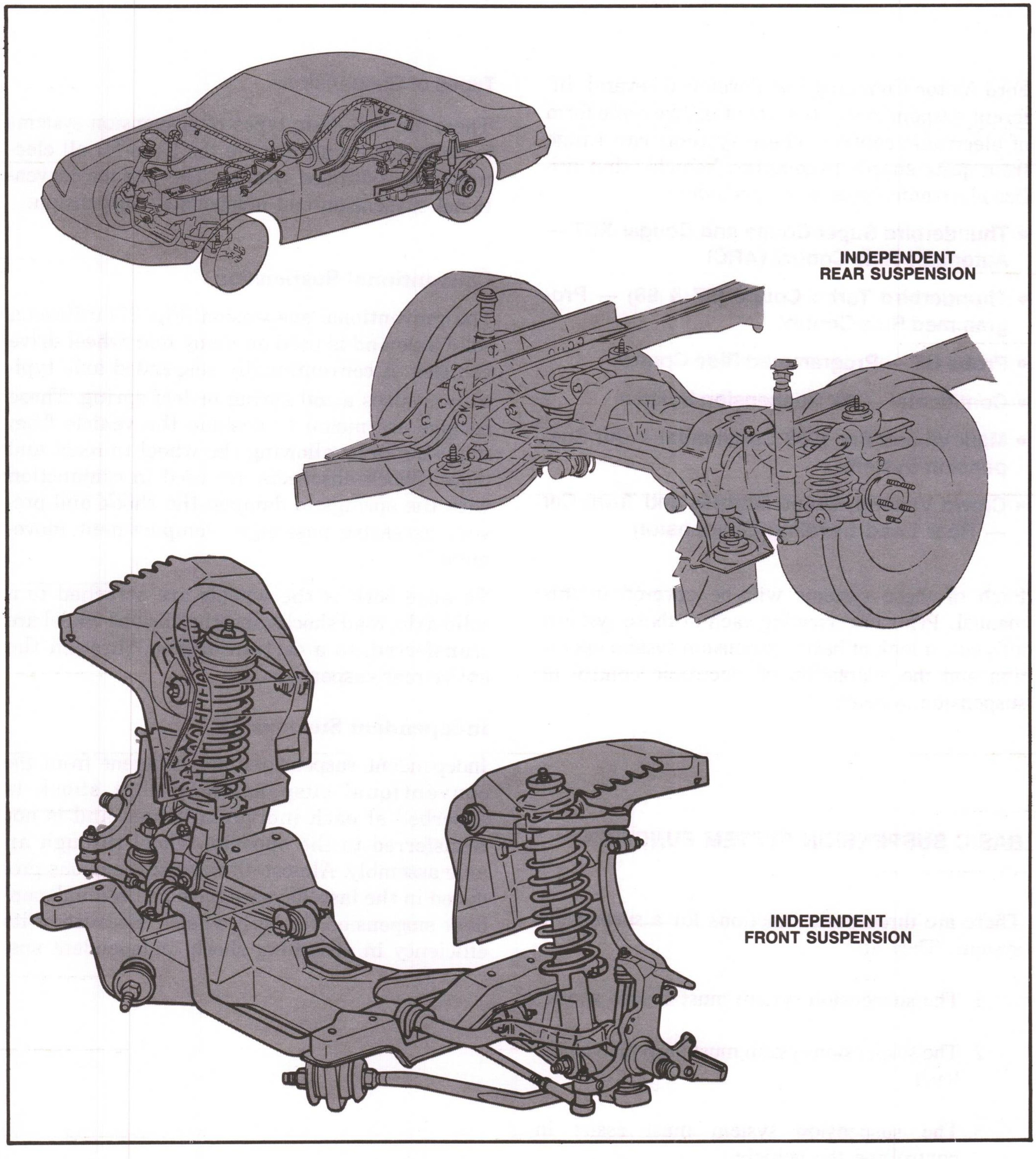

INDEPENDENT REAR SUSPENSION
INDEPENDENT FRONT SUSPENSION

Figure 38 — Super Coupe/XR7 Independent Suspension System

pension is seeing more and more use on all wheels as can be seen in this Super Coupe/XR7 suspension system (Fig. 38). Note that even though it is a rear wheel drive it is fully independent. This is made possible through the use of halfshafts and CV joints.

Major Shock Absorbing Components

The major shock absorbing components used in automotive applications are coil springs used in conjunction with shock absorbers, or a MacPherson strut which combines a coil spring with a shock absorber.

An excellent example of seeing all the independent suspension system components all rolled up into one can be seen in the Super Coupe/XR7 independent suspension system. This suspension utilizes MacPherson struts on the front suspension and a combination of shock absorbers and coil springs on the rear.

Obviously there are many more components in a suspension than just springs, shocks and struts. But, the fact is springs, shocks and struts are the major suspension devices which can be electronically controlled to modify suspension operation. Other components such as upper and lower control arms, stabilizer bars, etc. can't feasibly be controlled by computer.

ADAPTATION OF COMPUTER CONTROL TO ELECTRONICS

Typically a suspension system is designed to provide a sufficiently smooth ride, while maintaining adequate steering and handling. If a suspension is designed to an extreme, say for a soft ride, then steering and handling suffer. If the suspension is designed for excellent steering and handling, then the ride suffers. If a suspension could do both, instead of being a compromise between the two, it would be quite an innovation — that's where electronic control comes in to play.

If electronics are added to the system to monitor the driving conditions, then a computer can be used to change the suspension calibration in accordance to vehicle needs. This can be a simple change, such as for leveling the vehicle to compensate for extra luggage or weight (Fig. 39). It

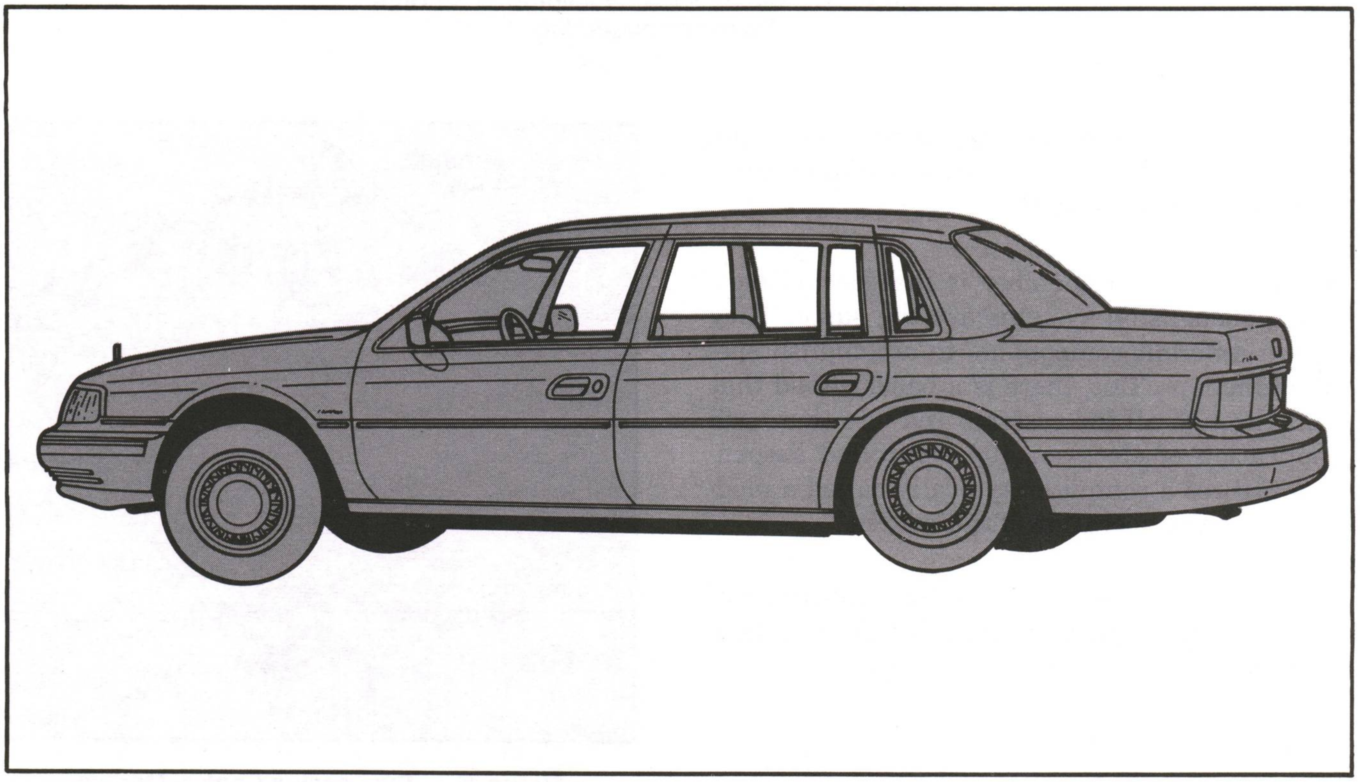


Figure 39 — Load Compensation

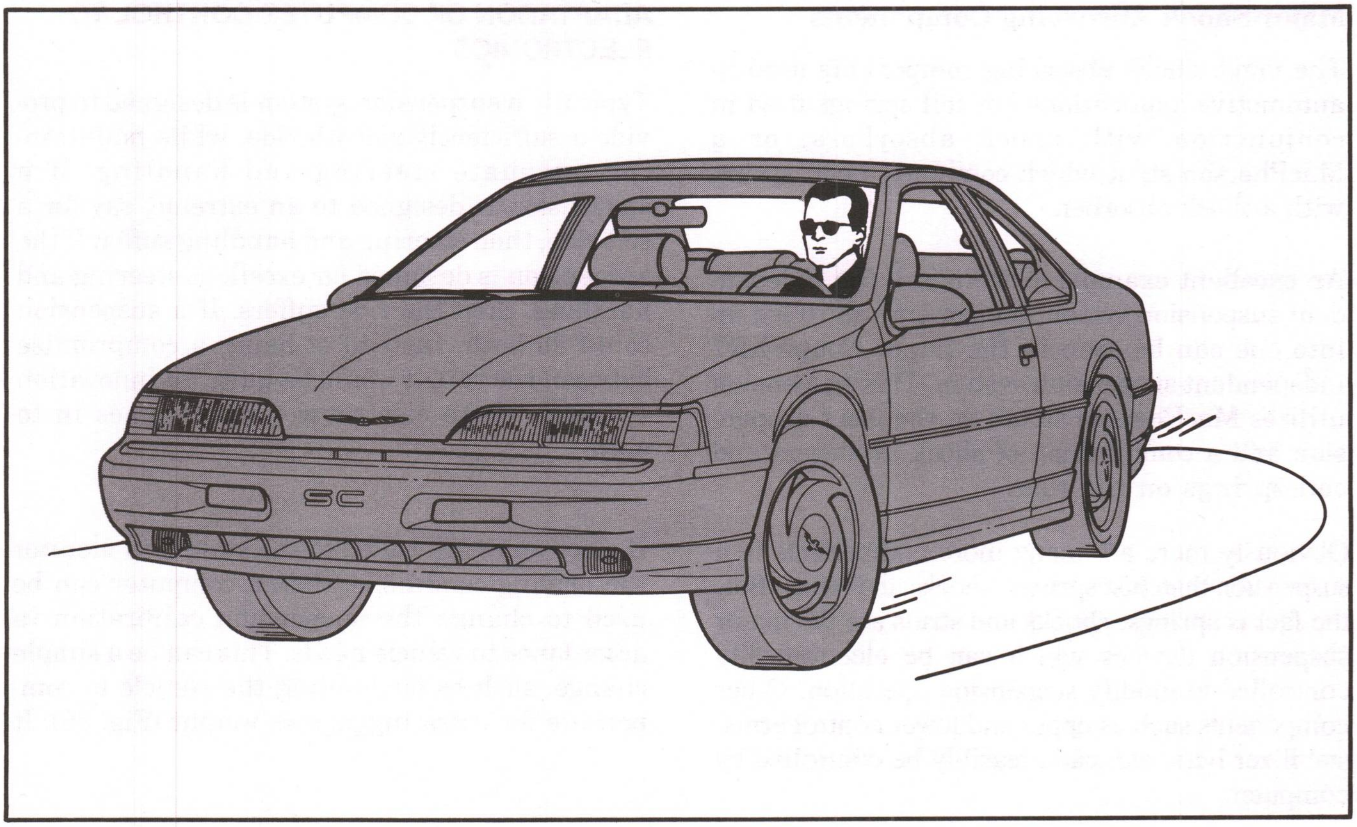


Figure 40 — Suspension Recalibration for High Speed Maneuvering

could also be a complex change to recalibrate the entire suspension action for evasive or high speed maneuvers (Fig. 40).

A basic point to remember is that not all electronic suspension systems are the same. They utilize different components to accomplish specific functions. But, there is a basic thread that runs through all the systems and it is that each application of electronically controlled suspension utilizes a computer, typically called a module, to control operation of the system.

The control module (Fig. 41) relies on a variety of inputs to make the decisions that effect suspension operation.

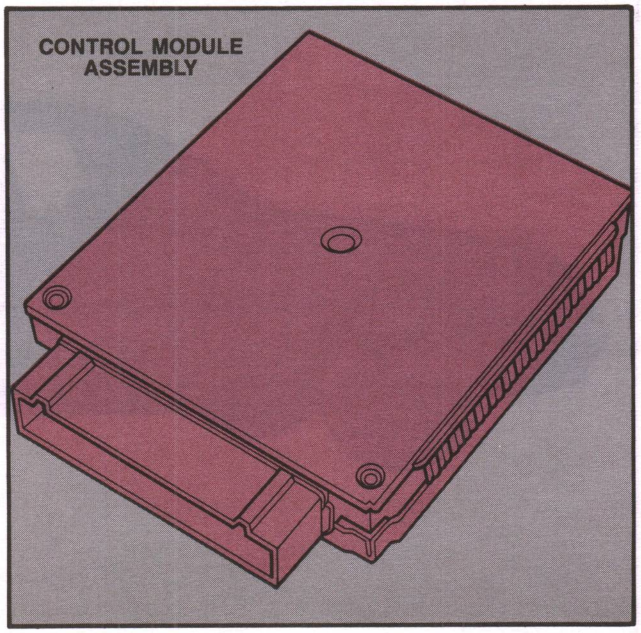


Figure 41 — Suspension Control Module

Input Devices

There are a variety of inputs to the module and they are not the same on all electronic suspensions. Let's take a look at the different inputs that are utilized. Being familiar with the input devices will allow increased understanding of the different systems and their function.

Speed Sensor

The speed sensor (Fig. 42) is a device which provides an indication of how fast the vehicle is travelling to the suspension module. This sensor is typically mounted on the transmission or transaxle output, although in some instances, such as the Probe GT, the sensor is integral with the speedometer. Output of the sensor is linear with speed. The faster the sensor spins, the greater the voltage output. As speed decreases, the sensor slows down and voltage output is decreased. High speed would indicate to the module that a firmer suspension would be required. The speed sensor is also used as an input for electronic steering systems and in some cases the electronic engine control and speed control systems.

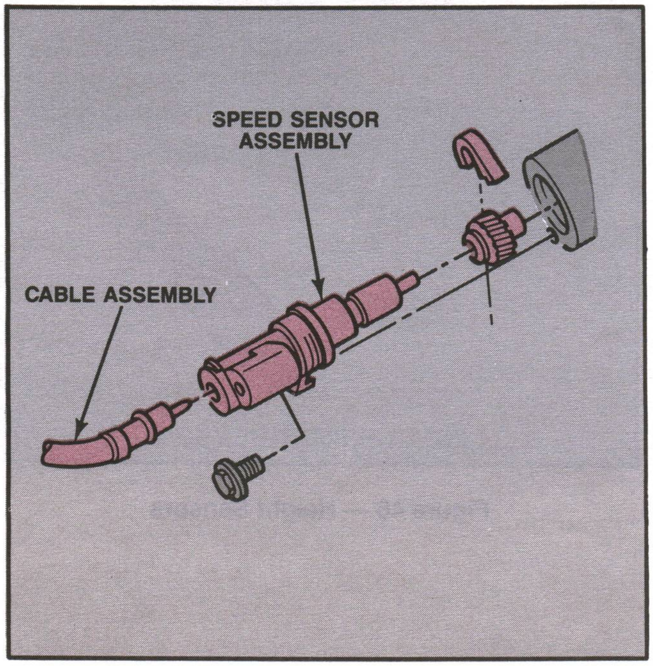


Figure 42 — Speed Sensor

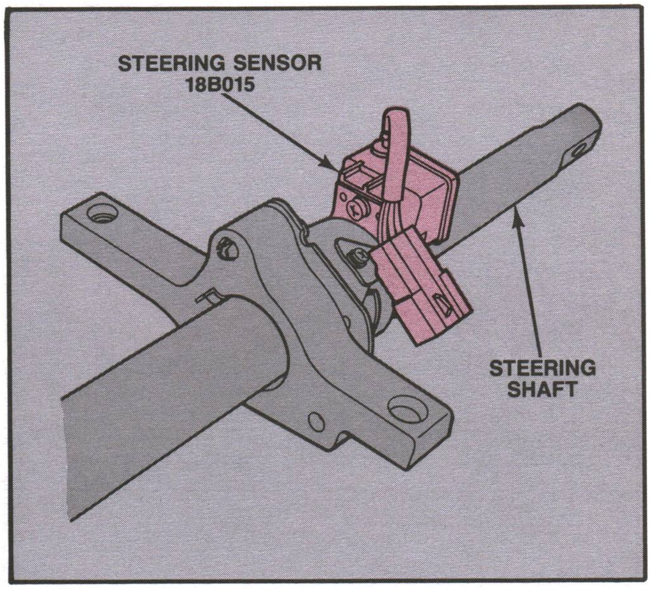


Figure 43 — Steering Wheel Rotation Sensor

Steering Wheel Rotation Sensor

The steering wheel rotation sensor (Fig. 43) is a photocell that measures how fast the steering wheel is being rotated and notes steering wheel position by determining the straight ahead position. This sensor is typically located in the steering column. Rapid steering wheel rotation or a hard turn above a certain preset speed would be an indication that a firmer suspension is required to perform an evasive maneuver. The steering wheel rotation sensor is also used as an input on some electronic steering systems.

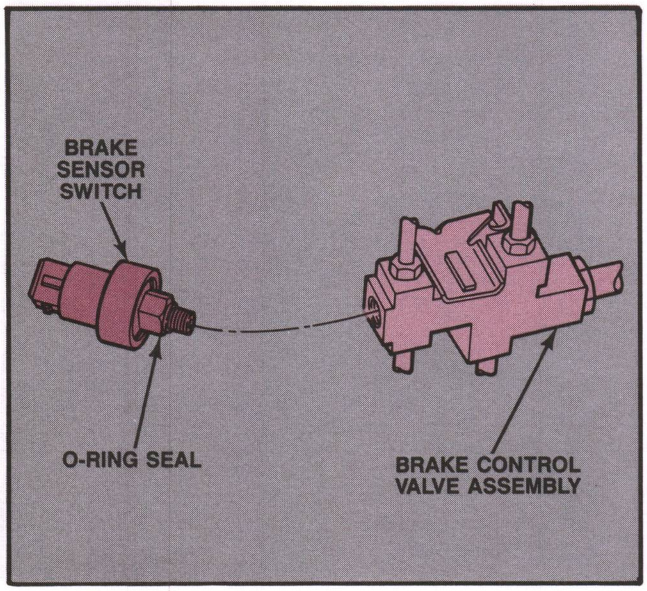

BRAKE SENSOR SWITCH
O-RING SEAL
BRAKE CONTROL VALVE ASSEMBLY

Figure 44 — Brake Sensor

Brake Sensor

The brake sensor (Fig. 44) is mounted on the master cylinder in some electronic suspension applications. Its primary purpose is to signal when heavy braking occurs so that the suspension can shift to a firm mode to compensate for it and provide increased driver control.

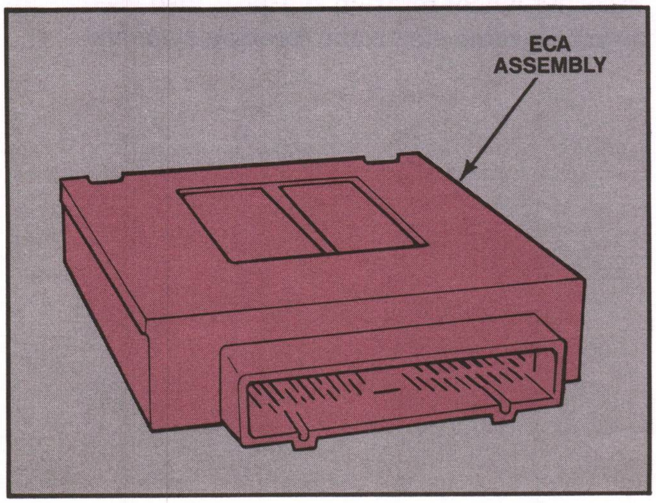

ECA ASSEMBLY

Figure 45 — ECA Assembly

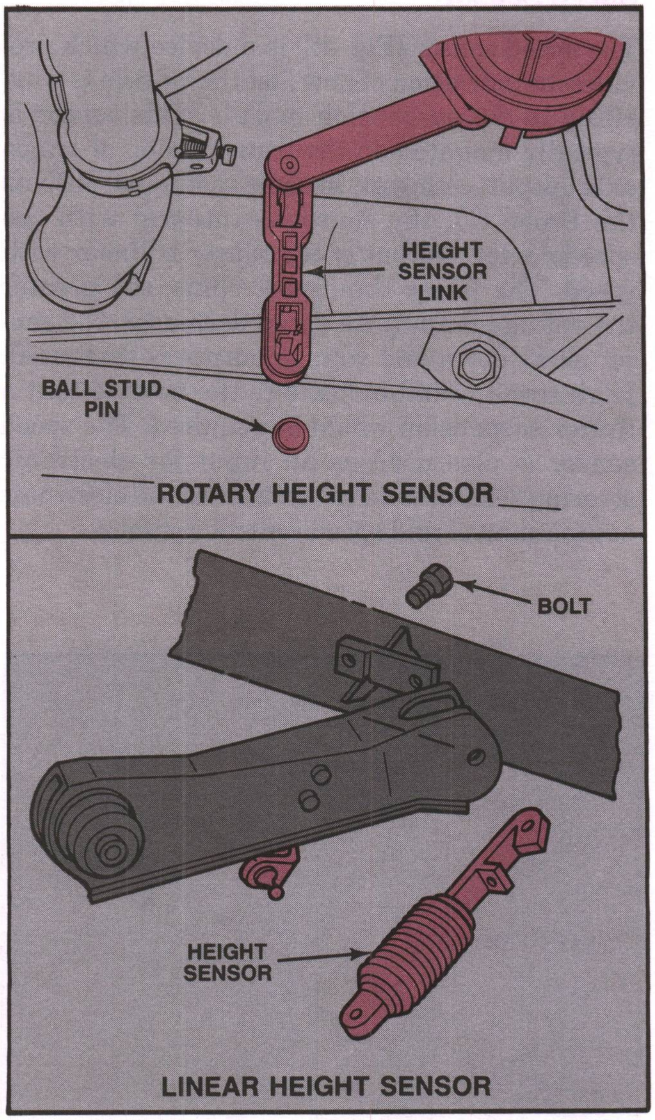

HEIGHT SENSOR LINK
BALL STUD PIN
ROTARY HEIGHT SENSOR
BOLT
HEIGHT SENSOR
LINEAR HEIGHT SENSOR

Figure 46 — Height Sensors

ECA Assembly

The ECA assembly (Fig. 45) is often used as an input to the suspension module to signal engine acceleration or deceleration. Rapid acceleration would signal a condition for a stiffer suspension to allow for increased vehicle control.

Height Sensors

Vehicle trim height is noted by height sensors. These are used to note changes in the load on the vehicle and allow the suspension to compensate for it, maintaining the ideal body height.

Height sensors do not all look the same (Fig. 46). Some are the linear type and others are a rotary design.

In addition to noting load changes within the vehicle and compensating for them, some height sensors are used to inform the suspension module of road undulations (such as railroad tracks). Road undulations, if they are severe, can cause the suspension to ground out resulting in a severe jolt to passengers. The height sensors can sense the road undulation and provide the information to the control module. The control module in turn can shift the suspension into a firm mode and prevent grounding out.

Other Inputs

Other inputs to the suspension module often include:

Ignition Switch — provides the suspension module with a signal that indicates switch position (engine OFF, Engine ON, etc.)

Ride Control Switch — This type of switch is used on some models to allow the operator to tailor the suspension to personal driving taste.

This covers many of the different inputs used on electronic suspensions. Some points to remember include the fact that these inputs will not typically be found all in one system. This is just a general look at common input devices. Also, there may be some other input devices found only on one specific system, such as door opening switch, instrument panel dimmer relay, and others.

Output Devices

Like the input devices, the output devices highlighted in this section are not found on every system. This is a general look at output devices.

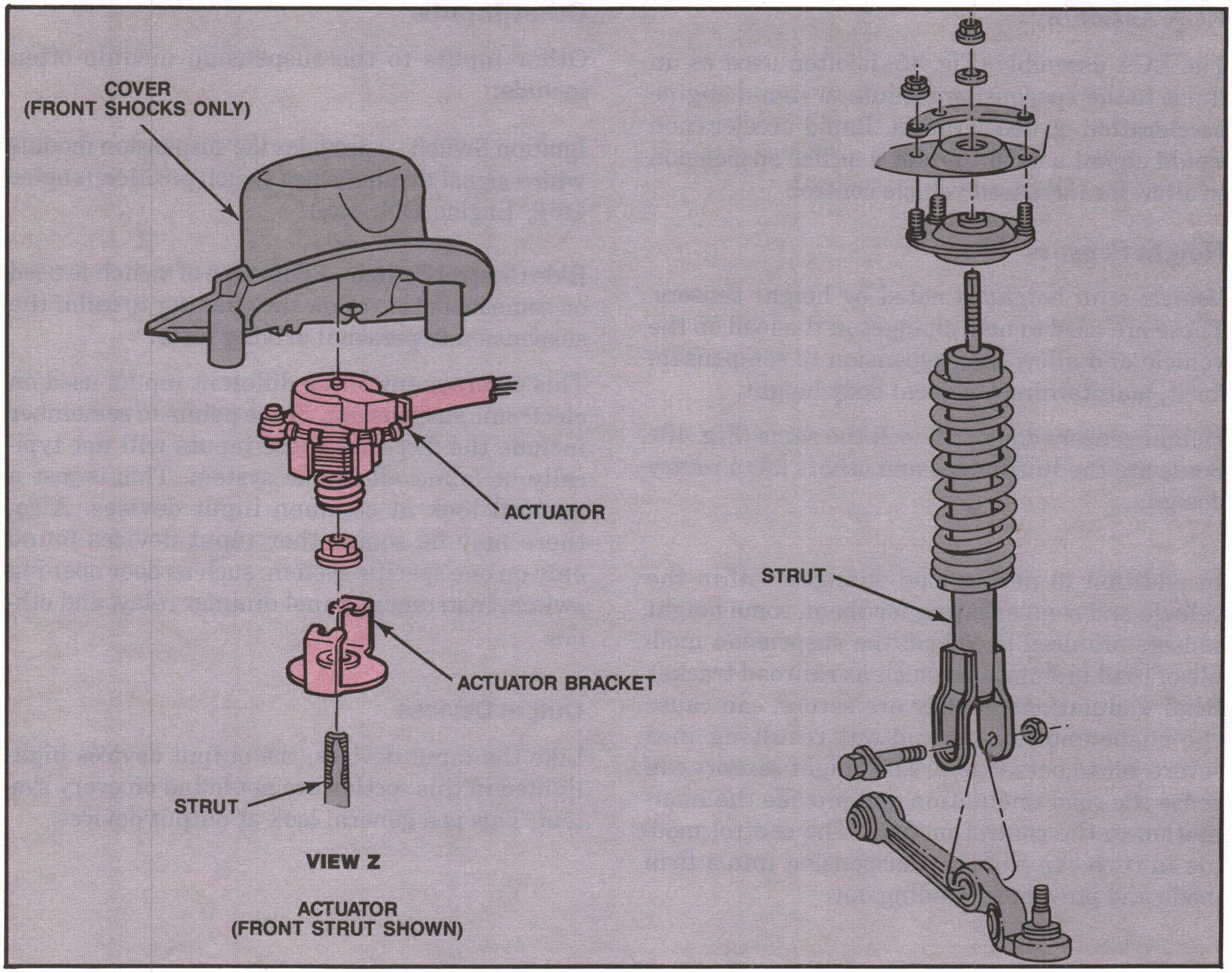

COVER
(FRONT SHOCKS ONLY)
ACTUATOR
ACTUATOR BRACKET
STRUT
VIEW Z
ACTUATOR
(FRONT STRUT SHOWN)
STRUT

Figure 47 — Actuator Assembly

Electronically Controlled Shocks and Struts

Electronically adjustable shocks and struts contain an actuator assembly (Fig. 47) which changes the internal valving on command from the suspension's control module.

Typically, the shock or strut is in a normal mode to allow for a smooth comfortable ride. But, a command from the module makes the actuator shift the valving of the shock or strut into a firm mode for increased control required for aggressive driving and positive road feel, or to prevent conditions of grounding the suspension (such as from severe road undulations).

The shift from soft to firm mode is immediate. This is required for the system to be able to react instantly to rapidly changing driving conditions.

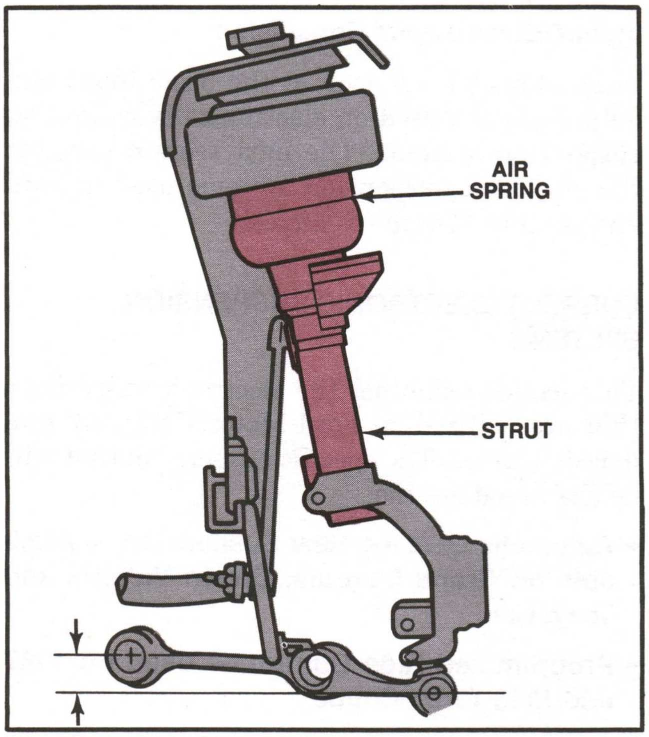


Figure 48 — Strut With Air Spring

Air Springs

The purpose of air springs are to maintain the vehicle trim height or to allow the suspension module to change the spring rate for a particular driving need. Air springs can come in many different shapes and configurations. In some instances the strut assemblies utilize an air spring rather than the conventional coil spring that typically wraps a strut (Fig. 48). Air springs also can be designed as an independent unit (Fig. 49).

Air Shocks

Air shocks (Fig. 50) are another actuating device that can be controlled by a computer. The most common use of air shocks are to raise or lower a vehicle to maintain proper trim height. In Ford applications, computer controlled air shocks are used only on the rear of some vehicles.

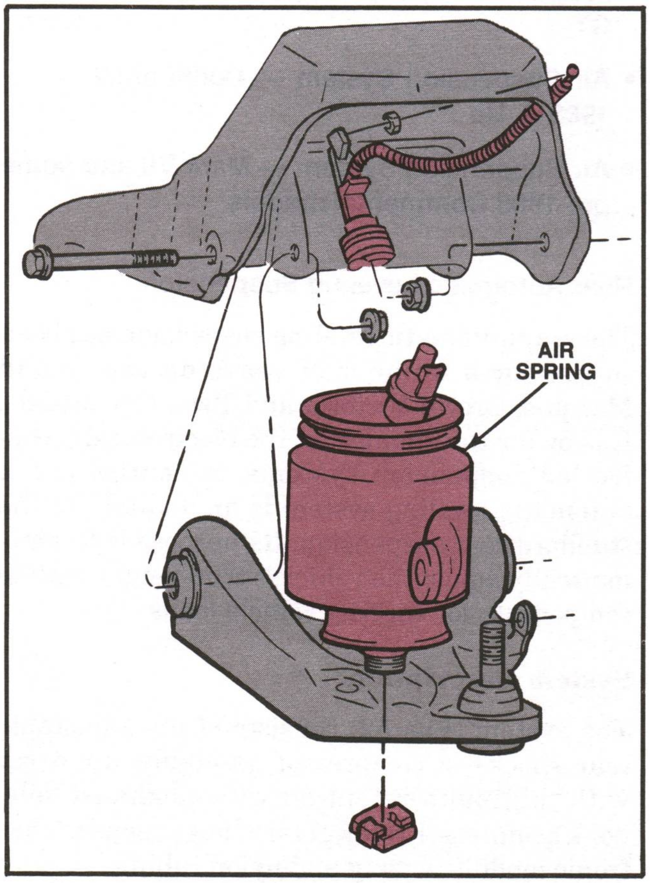
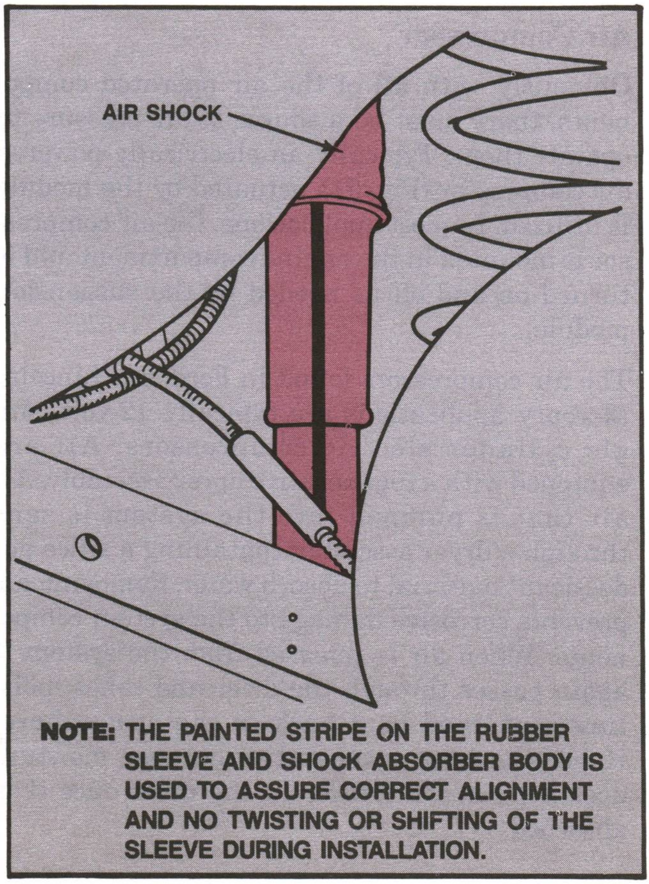


Figure 49 — Independent Air Spring



NOTE: THE PAINTED STRIPE ON THE RUBBER SLEEVE AND SHOCK ABSORBER BODY IS USED TO ASSURE CORRECT ALIGNMENT AND NO TWISTING OR SHIFTING OF THE SLEEVE DURING INSTALLATION.

Figure 50 — Air Shock

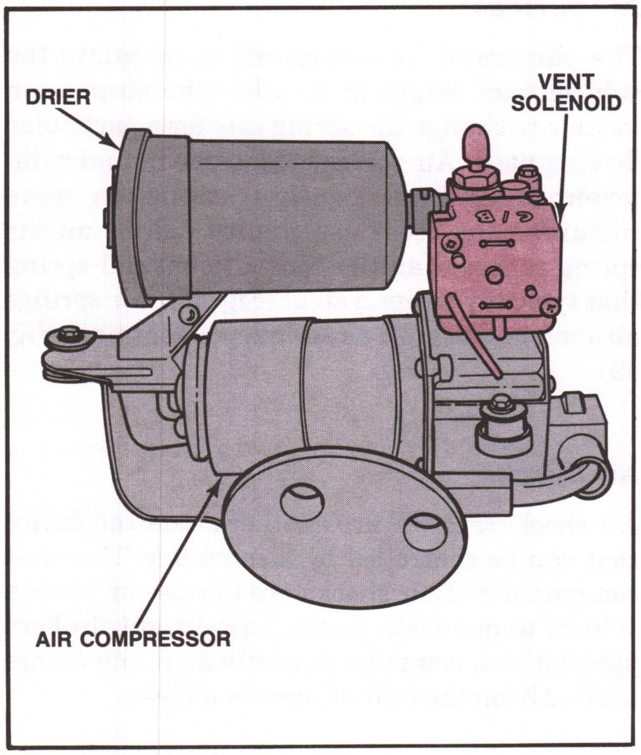


Figure 51 — Air Compressor

Air Compressor

Obviously with all of the air operated components, there must be a source of air pressure to operate them. Typically an electrically powered air compressor (Fig. 51), actuated by the module is utilized. In most applications, the air compressor is mounted in the engine compartment and is turned on and off as needed by the suspension module.

The air compressors found in Ford and Lincoln-Mercury applications are typically 12-volt, single cylinder electric compressors. All are equipped with a regenerative dryer assembly. All air that is pumped into the system is sent through a dryer assembly containing a silica gel dessicant material to absorb water. Removing air prevents corrosive damage to the system components. When air is released from the system it again passes through the drier and takes moisture contained in it back to the atmosphere. Hence the term regenerative because moisture does not remain forever in the drier once it is absorbed.

Input/Output Device Conclusion

This completes our look at the basic input and output devices used on electronically controlled suspension systems. The next section looks at the electronic suspension systems used in Ford and Lincoln-Mercury vehicles.

CURRENT ELECTRONIC SUSPENSION SYSTEMS

This section examines the electronic suspension that are utilized on Ford Motor Company produced vehicles. The specific suspension that will be examined are the:

- **Automatic Leveling Rear Suspension — Available on Grand Marquis, Crown Victoria and Town Car**
- **Programmed Ride Control — Used on 1987 and 1988 Turbo Coupe**
- **Automatic Ride Control — Used on Super Coupe and XR7**
- **Programmed Ride Control — Used on Probe GT**
- **Air Suspension System — Continental 1988 & Up**
- **Air Suspension System — Mark VII and some pre-1988 Continental models**

Rear Automatic Leveling Suspension

The rear automatic leveling suspension has been in use for a number of years on the Grand Marquis, Crown Victoria and Town Car models. It is by far the simplest of the electronically controlled suspension systems. Essentially, the automatic leveling system is an addition to the standard rear suspension. Its purpose is to automatically adjust the vehicle's trim height with to compensate for varying vehicle loads.

System Description

The system (Fig. 52) consists of air adjustable rear shocks, a compressor assembly, air dryer with minimum retention valve, exhaust solenoid, compressor relay, rotary height sensor, electronic module, wiring and nylon tubing.

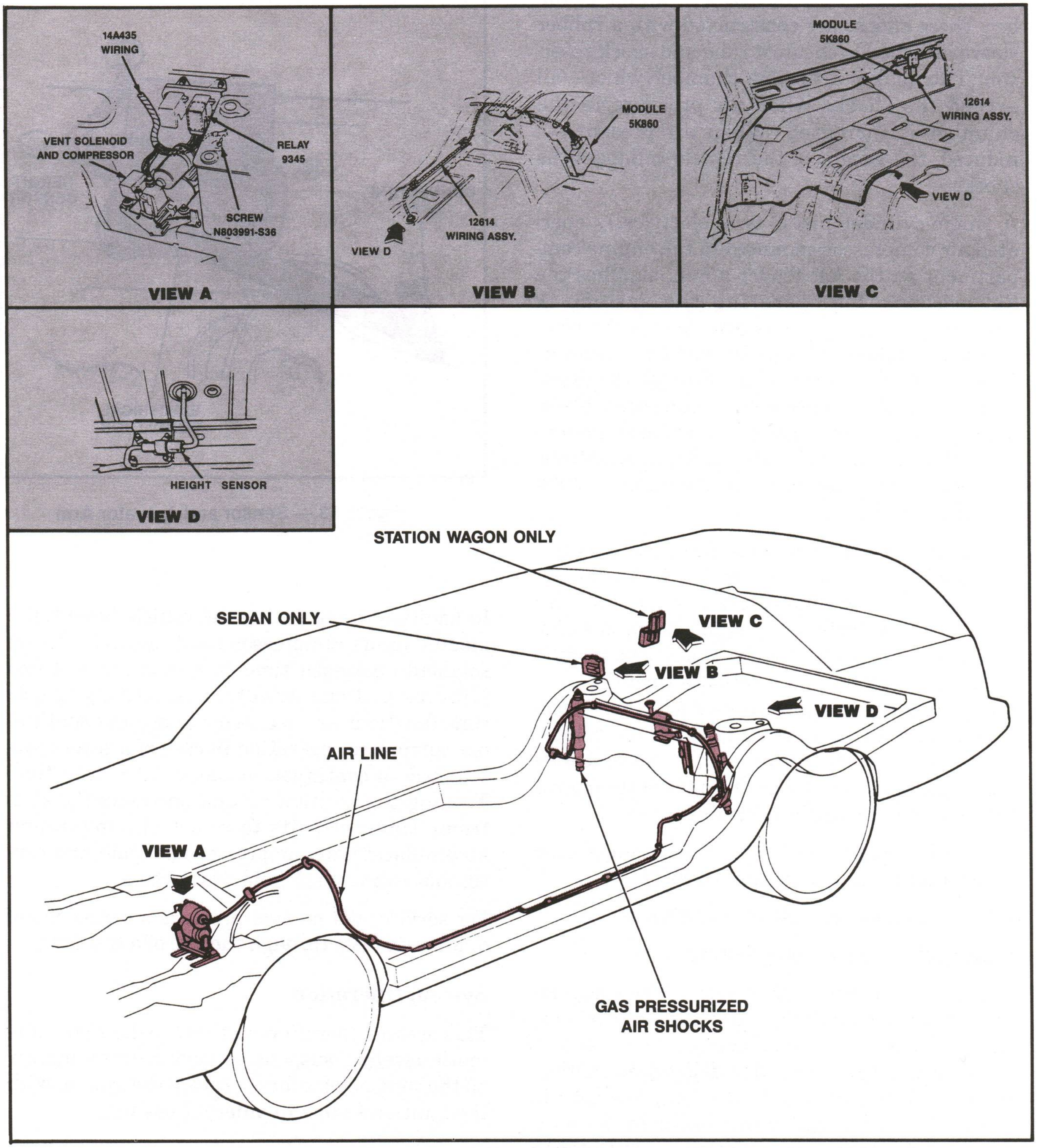

14A435
WIRING
VENT SOLENOID
AND COMPRESSOR
RELAY
9345
SCREW
N803991-S36
VIEW A
MODULE
5K860
12614
WIRING ASSY.
VIEW D
VIEW B
MODULE
5K860
12614
WIRING ASSY.
VIEW D
VIEW C
HEIGHT SENSOR
VIEW D
STATION WAGON ONLY
SEDAN ONLY
VIEW C
VIEW B
VIEW D
AIR LINE
VIEW A
GAS PRESSURIZED
AIR SHOCKS

Figure 52 — Rear Automatic Leveling Suspension

The adjustable air shock is essentially a conventional shock absorber enclosed in an air chamber. These shocks are constructed with a rubber sleeve attached to the dust tube and shock reservoir. This makes a flexible chamber which will extend the shocks when air pressure in the chamber is increased. When air pressure is reduced, the weight of the vehicle collapses the shocks.

A single-cylinder piston-type electrically operated air compressor, mounted in the engine compartment on the left fender apron, supplies the air pressure for operating the system. A regenerative-type dryer is attached to the compressor manifold. All airflow during raising or lowering of the vehicle passes through the dryer. A vent solenoid, located on the compressor manifold, controls air exhaustion. A minimum retention valve, located inside the air dryer, maintains pressure to the rear shocks to a minimum of 69-152 kPa (10-22 psi).

A module controls the amount of air pressure provided by the air compressor to the shock absorbers. The module determines the pressure according to vehicle trim height which is established by a single rear height sensor. The module activates the compressor relay to turn the compressor on, increasing pressure to lift the vehicle to the desired trim height. To lower the vehicle the module provides a command to the vent solenoid to release air pressure from the system until the desired trim height is attained.

The underbody height sensor is an electronic device that controls two basic circuits:

- **Compressor relay coil ground circuit**
- **Exhaust solenoid coil ground circuit**

To prevent continuous actuation of the compressor relay or exhaust solenoid circuits during normal ride motions, the microcomputer provides a continuous 7-13 second time delay before either circuit can be completed. The height sensor is mounted to the frame crossmember in the rear. The sensor actuator arm is attached to the rear upper left hand control arm by a short link (Fig. 53).

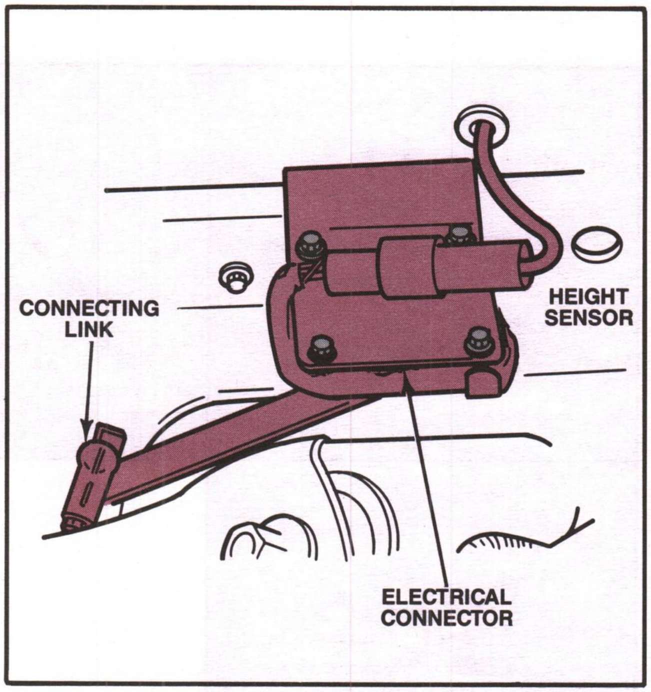


Figure 53 — Sensor and Actuator Arm

In addition to regulating the vehicle height, the module limits compressor run time and exhaust solenoid energized time to a maximum of two minutes and one minute, respectively. These time functions are necessary to prevent continuous compressor operation in case of a severe system leak or continuous exhaust valve operation. Turning the ignition off and on resets the electronic timer circuits to renew the maximum accumulating air compressor run time and continuous exhaust solenoid vent time.

For service, the module provides a series of self diagnostic tests through the use of a test lamp.

System Operation

This system operation section for the rear automatic leveling suspension concentrates mainly on the control logic for operating the system with the ignition switch in different positions.

Ignition in OFF Position

In this ignition switch position, the system will operate for 30 minutes after the ignition switch is turned from the RUN to OFF position. Then, the system is inoperable through the microcomputer.

The system will service down requests only (lower vehicle) as required during the 30 minutes except that the exhaust control is suspended after continuous ON operation for one minute. Turning the ignition switch to the ON position resets the operation. If the sensor arm moves to a NEUTRAl or LOW position, this function is also reset, and normal ignition off vent control resumes.

Ignition in RUN Position (Less Than 10 Seconds)

Under this condition, the system will not service any requests from the height sensor. But, the module will store the request in memory so that it can be reacted to at the appropriate time.

Ignition in RUN Position (More Than 10 Seconds)

Normal Control: The module will service requests from the height sensor after a 7 to 13 second continuous low (raise vehicle) or high (lower vehicle) signal.

The leveling system is activated when weight is added to, or removed from, the rear of the vehicle, to maintain the rear vehicle level at a predetermined rear suspension height. This is know as the vehicle's trim height (Dimension "D" in Shop Manual Specifications). Trim height is controlled by the height sensor. Distance of the body to ground will change with tire size and inflation pressure.

The system functions in the following manner. When a load is added to the vehicle, the body is forced downward, causing the height sensor's actuating arm to rotate upward, (low, out of trim) generating two sensor signals to the control module. After a continuous height sensor signal of 7 to 13 seconds (time delay), the module activates the air compressor (through a relay), sending air to the adjustable rear shock absorbers through the nylon tubing. As the body rises, the height sensor actuator arm continues rotating downward until the preset trim height is reached. The air compressor is turned off by the control module.

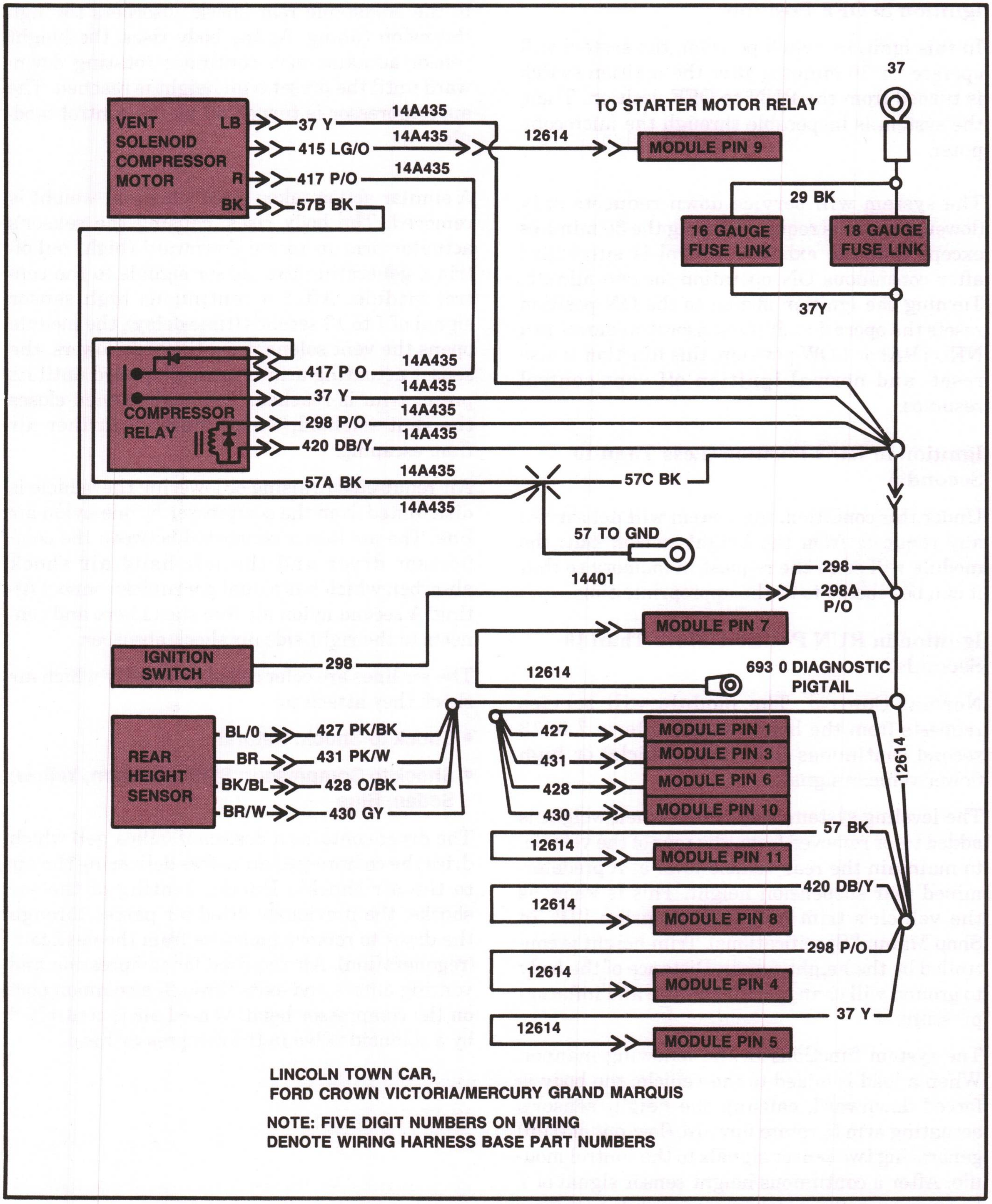
A similar action takes place whenever weight is removed. The body rises, causing the sensor's actuator arm to rotate downward (high, out-of-trim), generating two sensor signals to the control module. After a continuous high sensor signal of 7 to 13 seconds (time delay), the module opens the vent solenoid. As the body lowers, the sensor actuating arm is rotated upward until its preset trim is reached. The module then closes the vent solenoid, which prevents further air from escaping.

Air required for raising or lowering the vehicle is distributed from the compressor by one nylon air line. The air line is connected between the compressor dryer and the left hand air shock absorber, which has a dual port quick connect fitting. A second nylon air line starts here and connects to the right side air shock absorber.

The air lines are color coded to identify which air shock they attach to:

- **Shock to Shock: Natural**
- **Shock to Compressor: Station Wagon, Yellow; Sedan, Blue**

The dryer contains a desiccant (silica gel) which dries the compressed air before delivering the air to the air shocks. During venting of the air shocks, the previously dried air passes through the dryer to remove moisture from the desiccant (regeneration). Air required for compression and venting enters and exits through a common port on the compressor head. Vented air is controlled by a solenoid valve in the compressor head.


VENT SOLENOID COMPRESSOR MOTOR
LB
R
BK
37 Y
415 LG/O
417 P/O
57B BK
14A435
TO STARTER MOTOR RELAY
37
12614
MODULE PIN 9
29 BK
16 GAUGE FUSE LINK
18 GAUGE FUSE LINK
37Y
COMPRESSOR RELAY
417 P O
37 Y
298 P/O
420 DB/Y
57A BK
57C BK
57 TO GND
14401
298
298A P/O
MODULE PIN 7
IGNITION SWITCH
693 0 DIAGNOSTIC PIGTAIL
REAR HEIGHT SENSOR
BL/0
BR
BK/BL
BR/W
427 PK/BK
431 PK/W
428 O/BK
430 GY
427
431
428
430
MODULE PIN 1
MODULE PIN 3
MODULE PIN 6
MODULE PIN 10
57 BK
MODULE PIN 11
420 DB/Y
MODULE PIN 8
298 P/O
MODULE PIN 4
37 Y
MODULE PIN 5

LINCOLN TOWN CAR,
FORD CROWN VICTORIA/MERCURY GRAND MARQUIS

NOTE: FIVE DIGIT NUMBERS ON WIRING
DENOTE WIRING HARNESS BASE PART NUMBERS

Figure 54 — System Schematic

Electrical power to operate the load leveling system is distributed by the main body wiring harness. The wiring harnesses involved and their function in the leveling system are as follows (Fig. 54)

14401: Provides an extension of the ignition switch circuit 298 (ignition in RUN position input to the control module).

14A435: Supplies battery power to the system. Directly connects to the air compressor motor, air compressor relay and control module.

12614: Directly connects to the rotary height sensor, compressor motor, relay, vent solenoid and the control module.

CAUTION: The compressor relay and compressor vent solenoid have internal diodes for electrical noise suppression and therefore are polarity sensitive. Care must be taken when servicing these components not to switch the battery feed and ground circuits, or component damage will result.

Programmed Ride Control

The Programmed Ride Control (PRC) system was introduced originally in all 1987 Thunderbird Turbo Coupe models. It was Ford Motor Company's first fully electronic suspension system and provided a basis for future systems introduced on the 1988 Continental and 1989 Thunderbird Super Coupe and Cougar XR7. The Programmed Ride Control System was designed to automatically adjust the damping action of the front and rear shocks to provide a smooth ride and crisp, precise handling under a variety of driving conditions.

System Description

The primary feature of the Programmed Ride Control system is the ability to select either a firm (sport) suspension tuning or an automatic ride control.

The system is activated using a rocker switch (ride control switch) mounted on the instrument panel to the right of the steering column (Fig. 55).

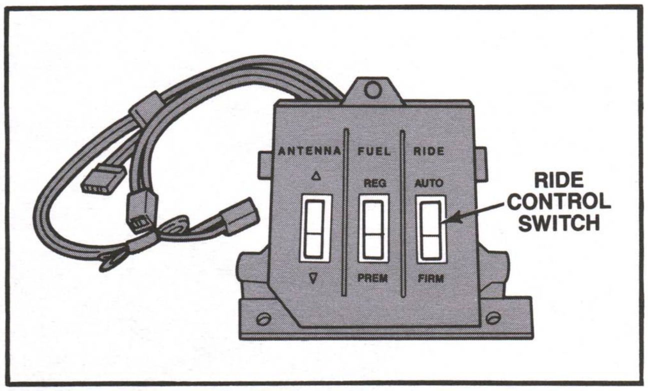


Figure 55 — Ride Control Switch

With the ride control switch in the FIRM position, the module adjusts the shock absorber damping to provide a firm (sport) suspension tuning.

With the ride control switch in the AUTO position, the module adjusts shock absorber damping to provide a soft (plush) ride during normal driving conditions. The module instantly changes suspension tuning to firm during hard braking, acceleration or cornering to provide improved handling at high speed.

A green FIRM RIDE indicator lamp (Fig. 56) is provided in the lower right corner of the tachometer. The lamp is normally illuminated whenever the suspension is firm. This includes any time the switch is in the FIRM position or any time the system switches to the firm tuning in the AUTO position.

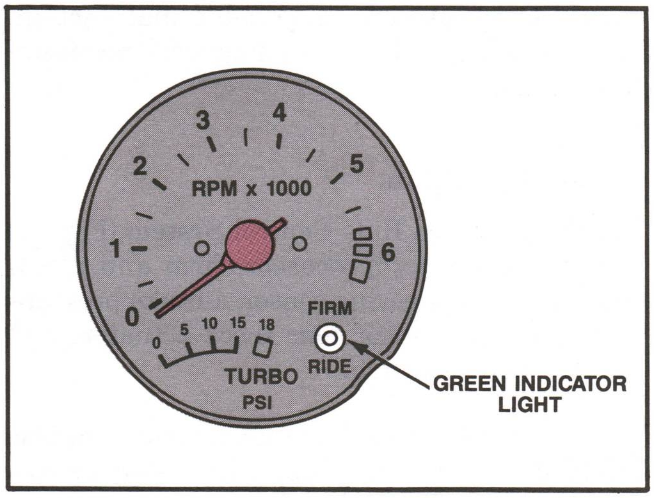


Figure 56 — Firm Ride Light

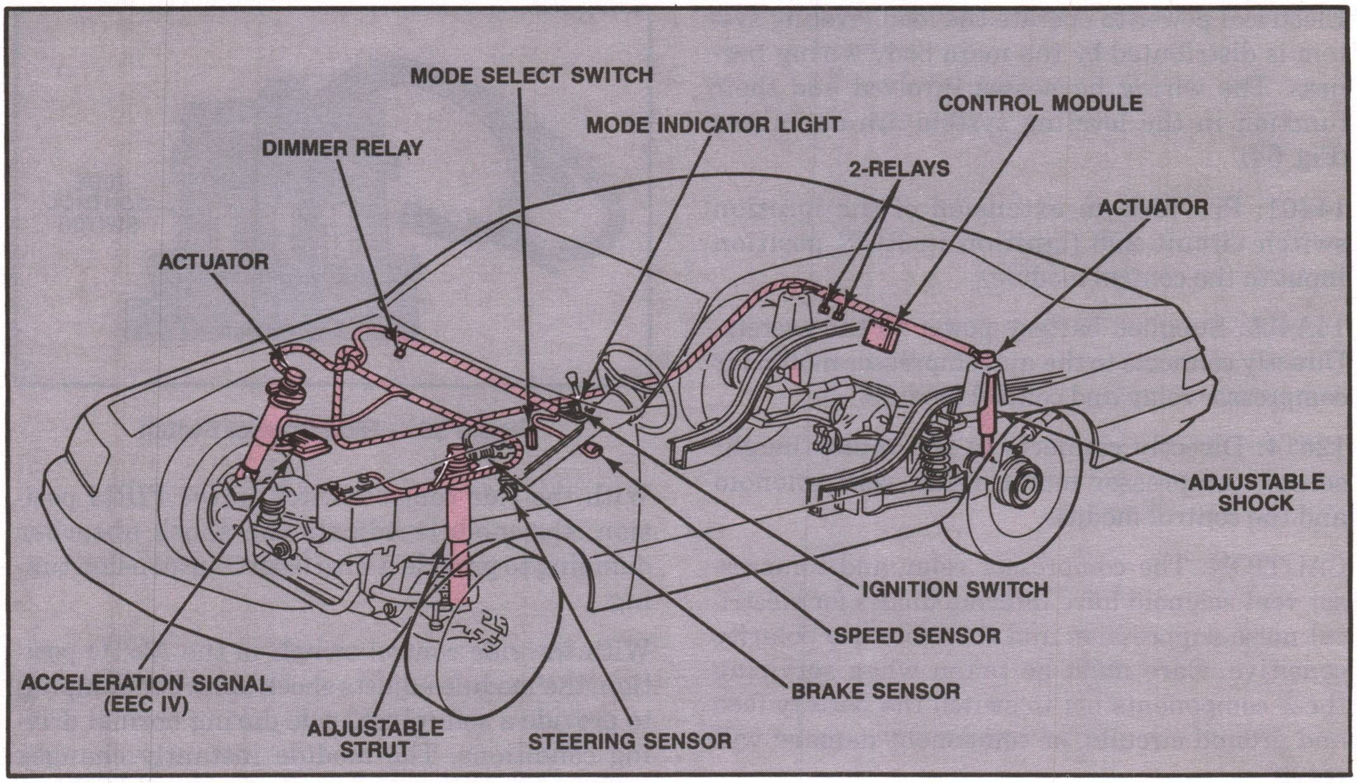

MODE SELECT SWITCH
MODE INDICATOR LIGHT
CONTROL MODULE
DIMMER RELAY
2-RELAYS
ACTUATOR
ACTUATOR
ADJUSTABLE SHOCK
IGNITION SWITCH
SPEED SENSOR
BRAKE SENSOR
ACCELERATION SIGNAL (EEC IV)
ADJUSTABLE STRUT
STEERING SENSOR

Figure 57 — Programmed Ride Control System

In the event of a system malfunction, the indicator lamp will flash on and off. Moving the ride control switch between positions will usually clear any false malfunction indication. If the indicator lamp continues to flash, the system should be checked for a possible malfunction. This check is detailed in the diagnostic portion of this manual.

System Operation

The Programmed Ride Control System (Fig. 57) consists of a microprocessor, firm and plush shock relays, a steering sensor, a brake pressure sensor, a speed sensor, four shock actuators and the ride control switch.

When the ride control switch is placed in the FIRM position, the plush ride relay is de-energized, the firm ride relay is energized and the system is locked into the firm ride mode. No adjustment of the suspension will occur, regardless of sensor input. The indicator lamp in the lower right corner of the tachometer will glow continuously in this mode.

When the switch is placed in the AUTO position, the firm ride relay is de-energized, the plush ride relay is energized and the vehicle will operate in the plush ride mode. The control assembly will automatically switch the system to a firm ride when sensor input(s) indicates a large change in vehicle direction or speed. In this condition, the indicator lamp will glow any time the system switches to the firm ride mode.

During the first 80 seconds of operation, the system will not respond to changes in vehicle direction. This is because the PRC control module must calculate the straight ahead position. This delay could increase to several minutes if several tight turns occur during the first few minutes of operation. It will, however, continue to respond to all other sensor inputs.

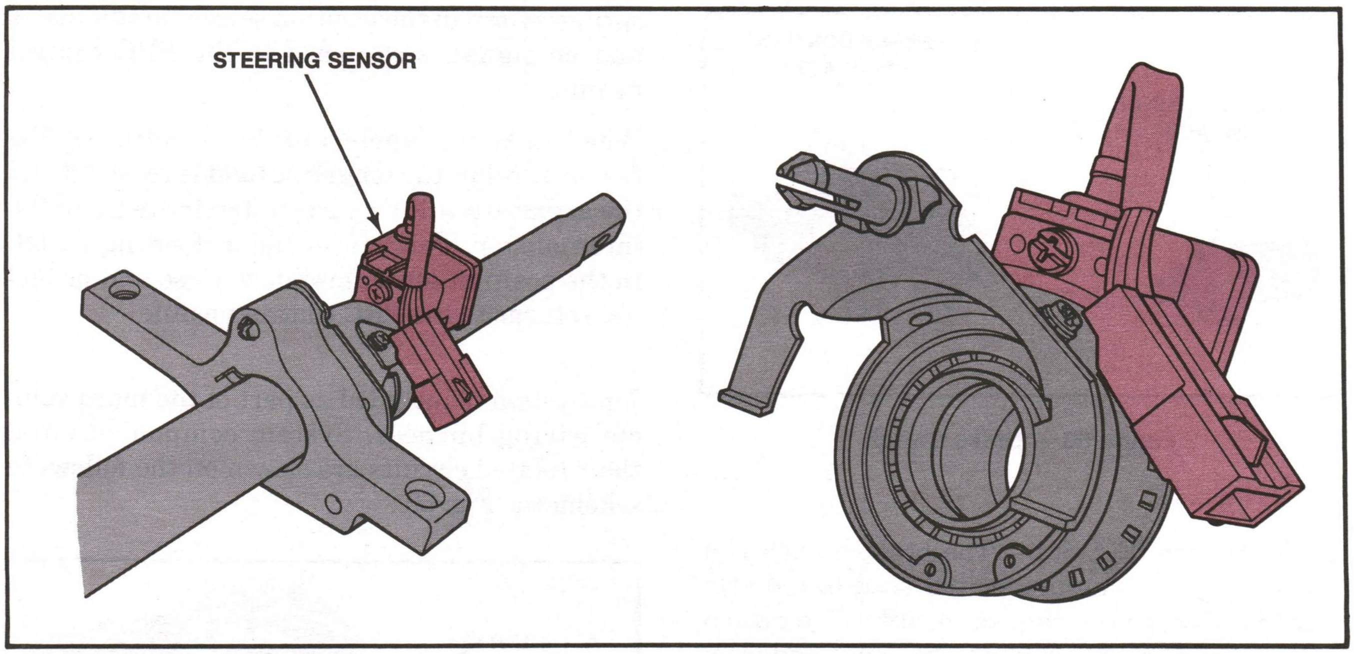


Figure 58 — Steering Sensor

The system components operate in the following manner:

Steering Sensor (Fig. 58) — The steering sensor is used to determine changes in vehicle direction. The sensor is located on the steering shaft just above the column boot. The sensor ring rotates with the steering shaft. A series of slits pass a pair of photoelectric eyes that generate a signal to the control module. From this signal, the control module determines the vehicle's turning angle and then compares this with vehicle speed to calculate lateral acceleration. The system will remain in the plush ride mode during mild turning maneuvers and automatically switch to the firm ride mode when lateral acceleration exceeds 0.3g. The system will return to the plush ride mode seven seconds after the lateral acceleration drops below 0.3g.

Speed Sensor (Fig. 59) — The speed sensor is the same input component used for the speed control system and the EEC system. The sensor, mounted on the transmission extension housing, is driven by the transmission output shaft and generates a low voltage signal to the control module. The control module uses the speed signal in addition to other sensors to determine when the system should be switched to the firm ride mode. As mentioned before, this occurs when vehicle speed and steering angle combine to produce lateral acceleration of 0.3g or greater. If vehicle speed exceeds 133 km/h (83 mph), the system will automatically switch to the firm ride mode and remain there until speed is reduced to less than 118 km/h (74 mph). The system will return to the plush ride mode a few seconds after these conditions are met.

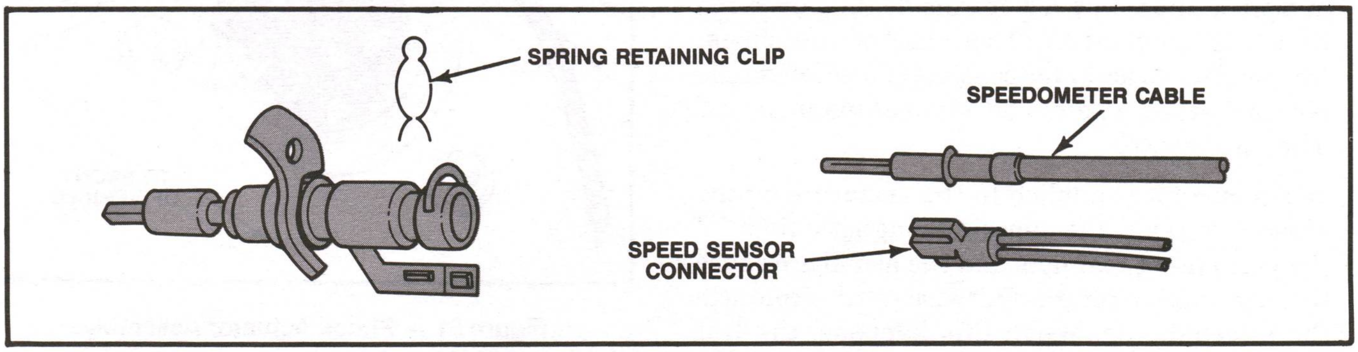


Figure 59 — Speed Sensor

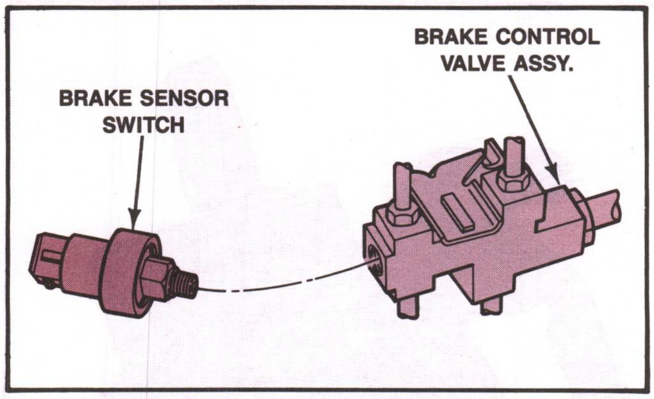


Figure 60 — Brake Switch

Brake Switch (Fig. 60) – The brake switch is a normally open pressure switch used to indicate hard braking to the control module. The switch is threaded into the brake control valve and measures front brake pressure. When hydraulic pressure to the front brakes exceeds 400 psi, the switch closes, returning a signal to the control module. The module will then switch the system to the firm ride mode to reduce the front suspension nose dive. The system will return to the plush ride mode four seconds after the brake switch opens.

Throttle Position Signal – The system control module also monitors throttle position through the EEC system. When the switch is in the AUTO position, a throttle opening of 90% or greater will cause the system to switch to the firm ride mode. Once the throttle is closed to less than 90%, the system will return to the plush ride mode, providing all other sensors indicate a normal driving condition for four seconds.

Shock Actuator Assembly (Fig. 61) – The actuators are located at the top of each shock absorber and strut and rotate a shaft inside the piston rod to change the internal valving of the shock. Internally, the actuator consists of a small single pole armature, a pair of permanent magnets and a position switch.

When current is applied to the armature by the plush ride relay, the opposing magnetic fields of the permanent magnets and the armature cause the armature to rotate clockwise until it contacts the internal stop. When this happens, the leaf spring switch in the position sensor circuit opens and no signal is returned to the PRC control module.

When current is applied to the armature by the firm ride relay, the magnetic field is reversed and the armature will rotate counterclockwise to the internal stop. This causes the leaf spring switch in the position sensor circuit to close and no signal returns to the PRC control module.

The system is included as part of the main vehicle wiring harness. System components and their related circuits are shown on the following schematic (Fig. 62).

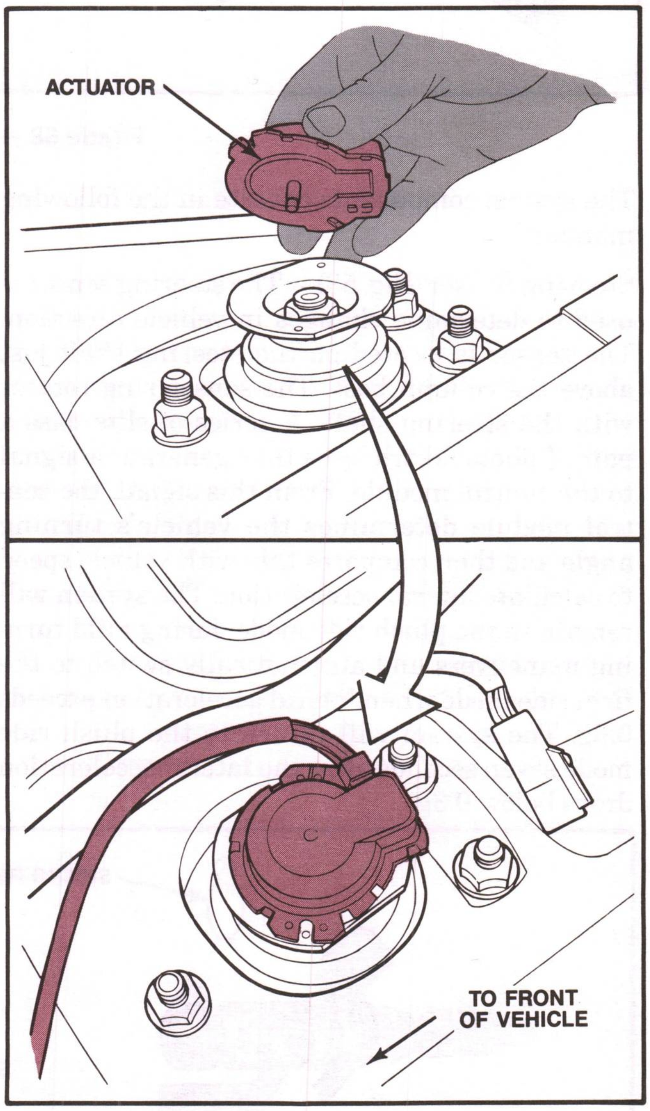


Figure 61 — Shock Actuator Assembly

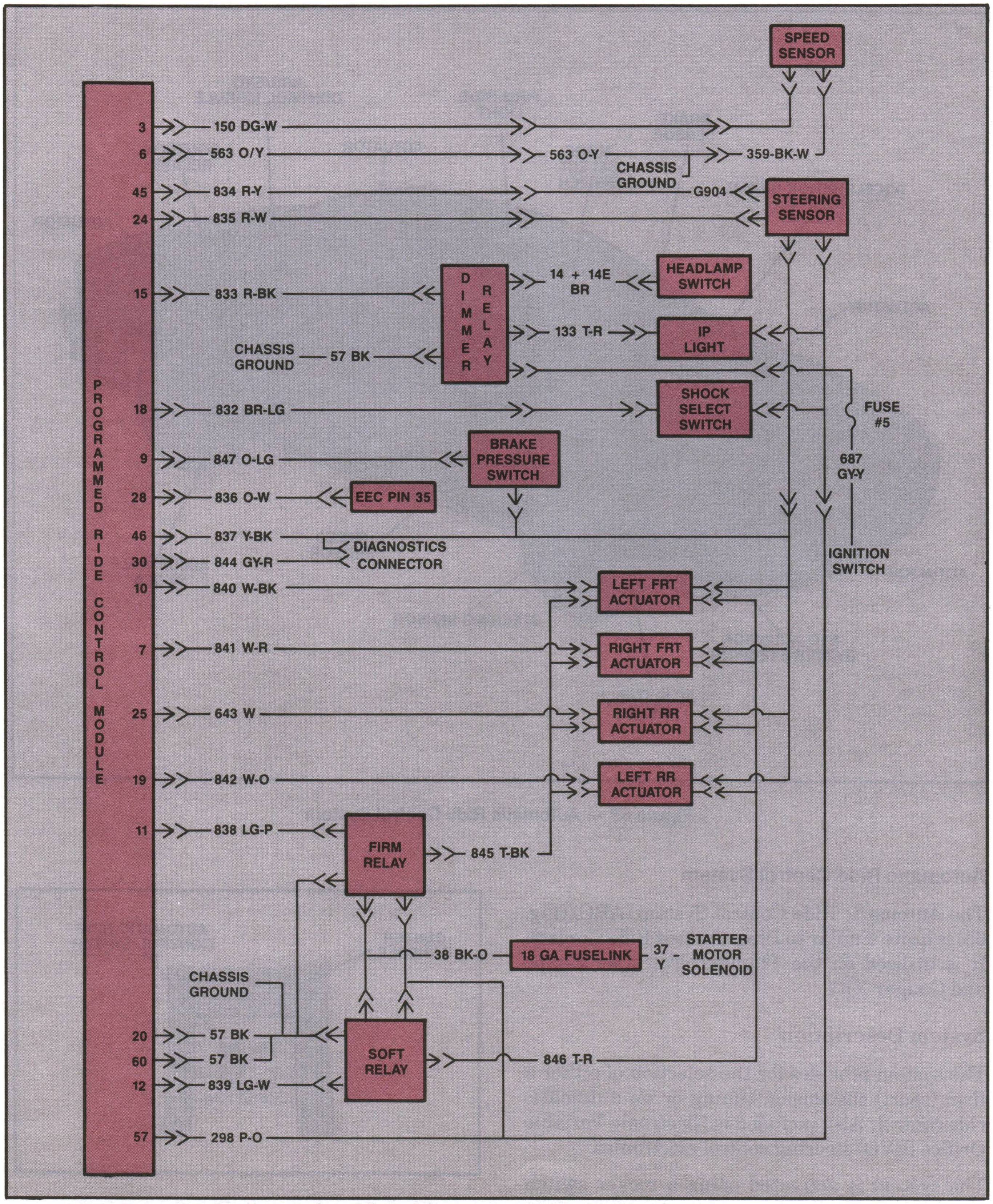

SPEED SENSOR
PROGRAMMED RIDE CONTROL MODULE
3
150 DG-W
6
563 O/Y
563 O-Y
359-BK-W
CHASSIS GROUND
G904
45
834 R-Y
24
835 R-W
STEERING SENSOR
15
833 R-BK
DIMMER RELAY
14 + 14E BR
HEADLAMP SWITCH
CHASSIS GROUND
57 BK
133 T-R
IP LIGHT
18
832 BR-LG
SHOCK SELECT SWITCH
FUSE #5
9
847 O-LG
BRAKE PRESSURE SWITCH
687 GY-Y
28
836 O-W
EEC PIN 35
46
837 Y-BK
DIAGNOSTICS CONNECTOR
30
844 GY-R
IGNITION SWITCH
10
840 W-BK
LEFT FRT ACTUATOR
7
841 W-R
RIGHT FRT ACTUATOR
25
643 W
RIGHT RR ACTUATOR
19
842 W-O
LEFT RR ACTUATOR
11
838 LG-P
FIRM RELAY
845 T-BK
38 BK-O
18 GA FUSELINK
37 - Y
STARTER MOTOR SOLENOID
CHASSIS GROUND
20
57 BK
60
57 BK
SOFT RELAY
846 T-R
12
839 LG-W
57
298 P-O

Figure 62 — Programmed Ride Control System Schematic

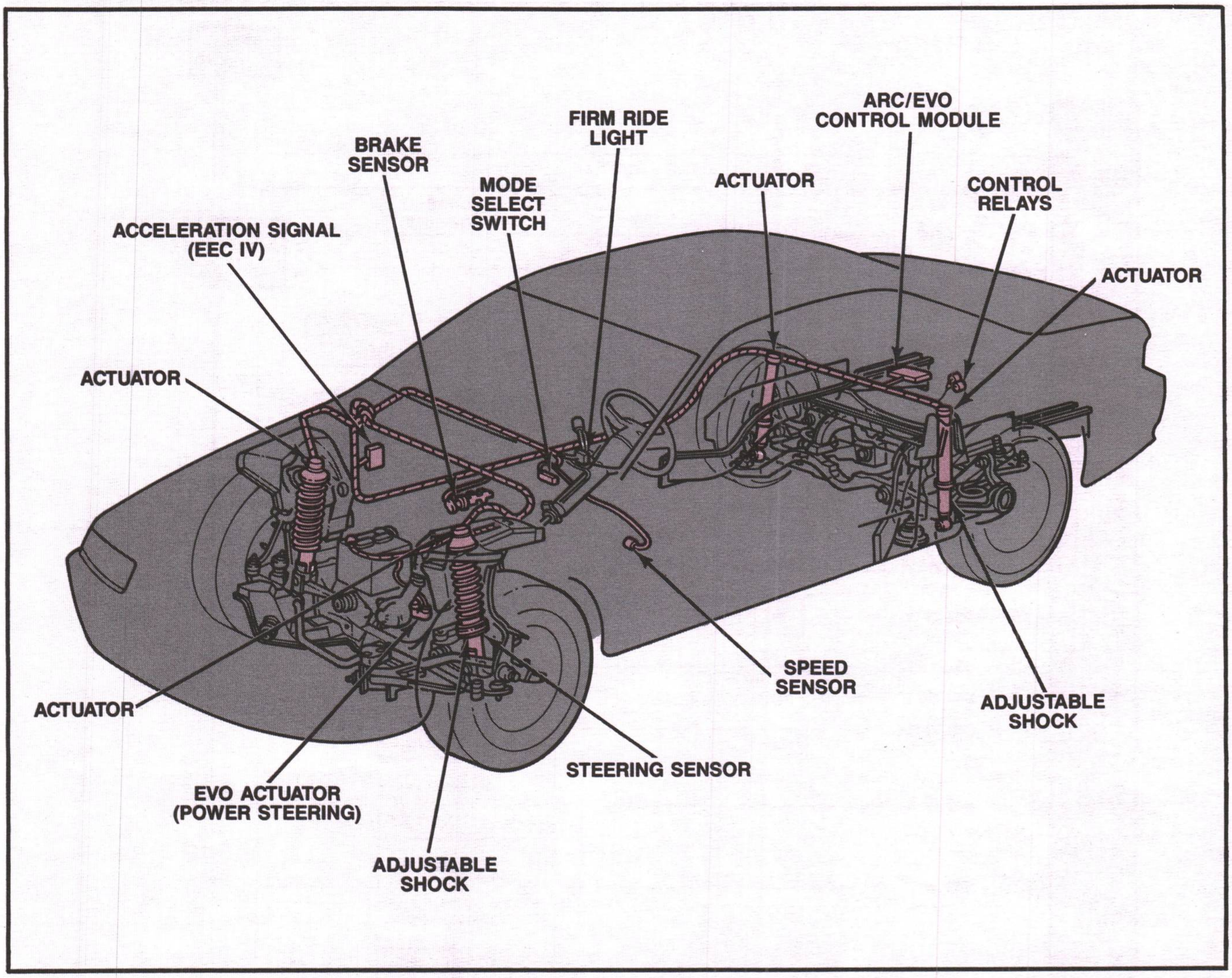

ARC/EVO CONTROL MODULE
FIRM RIDE LIGHT
BRAKE SENSOR
MODE SELECT SWITCH
ACTUATOR
CONTROL RELAYS
ACCELERATION SIGNAL (EEC IV)
ACTUATOR
ACTUATOR
SPEED SENSOR
ADJUSTABLE SHOCK
ACTUATOR
STEERING SENSOR
EVO ACTUATOR (POWER STEERING)
ADJUSTABLE SHOCK

Figure 63 — Automatic Ride Control System

Automatic Ride Control System

The Automatic Ride Control System (ARC) (Fig. 63) is quite similar to Programmed Ride Control. It is utilized on the Thunderbird Super Coupe and Cougar XR7.

System Description

The system provides for the selection of either a firm (sport) suspension tuning or an automatic ride control. Also included is Electronic Variable Orifice (EVO) steering control electronics.

The system is activated using a rocker switch mounted on the center console to the right of the driver's seat (Fig. 64).

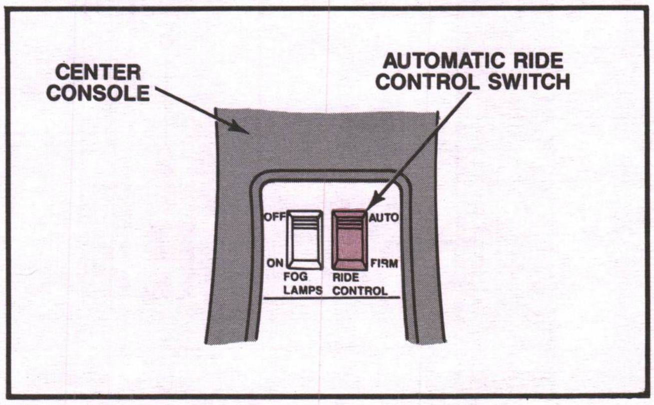

CENTER CONSOLE
AUTOMATIC RIDE CONTROL SWITCH
OFF
ON
FOG LAMPS
AUTO
FIRM
RIDE CONTROL

Figure 64 — Automatic Ride Control Switch

With the ride control switch in the FIRM position, the ARC module adjusts shock absorber damping to provide a firm (sport) suspension tuning.

With the ride control switch in the AUTO position, the module adjusts shock absorber damping to provide a soft ride during normal driving conditions. The ARC computer instantly changes suspension tuning to firm during hard braking, acceleration, cornering or high speed to provide improved handling.

A green FIRM RIDE indicator lamp is provided in the lower right corner of the instrument panel (Fig. 65). The lamp is normally illuminated whenever the suspension is firm. This includes any time the switch is in the FIRM position or any time the system switches to the firm tuning in the AUTO switch position.

In the event of a system malfunction, the indicator lamp will flash on and off. Moving the ride control switch between positions will usually clear any false or intermittent malfunction indications. If the indicator lamp continues to flash, the system should be checked for a possible malfunction.

System Operation

In the AUTO mode, the automatic ride control system module monitors the following conditions to determine when additional shock absorber damping is required for improved handling:

- **Brake Hydraulic Pressure**
- **Throttle Position**
- **Super Charger Boost**
- **Steering Wheel Angle**
- **Vehicle Speed**

Any one of the following approximate conditions will cause the shock absorber and strut damping to switch to FIRM:

- **Hard braking: Brake hydraulic pressure above 2758 kPa (400 psi)**
- **More than 90 percent of full throttle**
- **Hard acceleration causing super charger boost**
- **Hard cornering: above 0.35g lateral acceleration**
- **Vehicle speeds above 133 km/h (83 mph)**

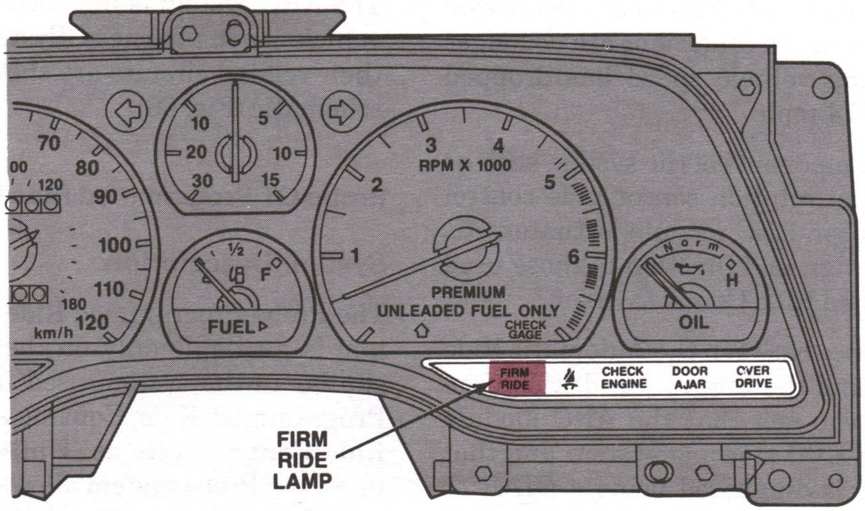


Figure 65 — Firm Ride Indicator

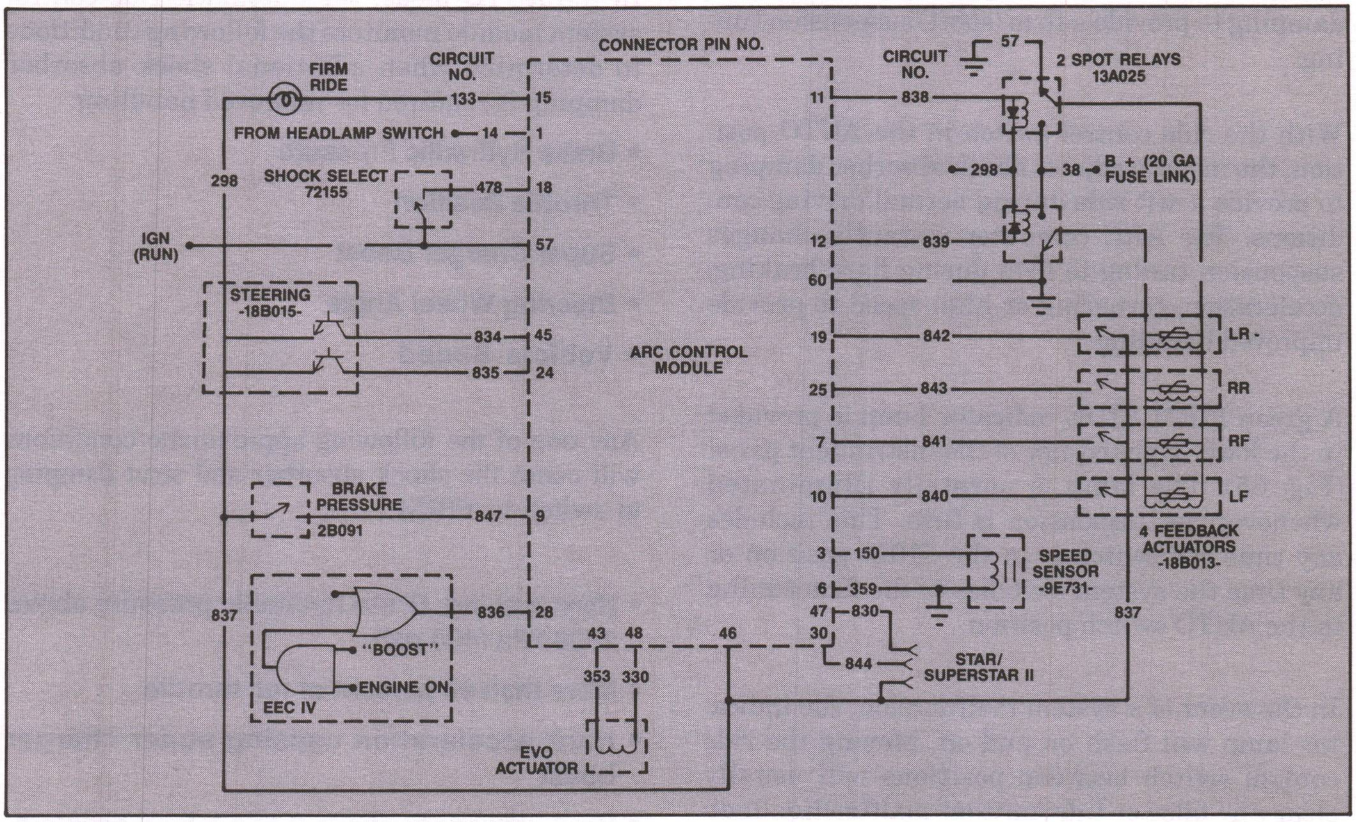

CONNECTOR PIN NO.
FIRM RIDE
CIRCUIT NO.
133
15
FROM HEADLAMP SWITCH
14
1
298
SHOCK SELECT 72155
478
18
IGN (RUN)
57
STEERING -18B015-
834
45
835
24
ARC CONTROL MODULE
BRAKE PRESSURE
2B091
847
9
837
836
28
"BOOST"
ENGINE ON
EEC IV
43
48
353
330
46
EVO ACTUATOR
CIRCUIT NO.
57
2 SPOT RELAYS 13A025
11
838
298
38
B + (20 GA FUSE LINK)
12
839
60
19
842
LR -
25
843
RR
7
841
RF
10
840
LF
4 FEEDBACK ACTUATORS -18B013-
3
150
SPEED SENSOR -9E731-
6
359
47
830
30
844
837
STAR/ SUPERSTAR II

Figure 66 — Automatic Ride Control System Schematic

The shock damping will return to the softer ride a few seconds after these conditions are no longer present, providing vehicle speed has dropped below 118 km/h (74 mph).

The individual components of the system such as the steering wheel rotation sensor, ride control switch, speed sensor, EEC module, actuator, etc. are similar in design and function to those used in the Programmed Ride Control system.

The basic difference between the Automatic Ride Control system and the Programmed Ride Control system are the fact that the ARC module also controls the EVO steering system and that the ARC system is diagnosed using a STAR or Super STAR II tester.

The ARC system is included as part of the main vehicle wiring harness. System components and their related circuits are shown on the following schematic (Fig. 66).

Probe GT Programmed Ride Control System

System Description

The Probe Programmed Ride Control (PRC) System is available only on the GT models and is similar to the system used in the Turbo Coupe Programmed Ride Control and the Automatic Ride Control systems. Unlike these other systems, the Probe system allows the driver to select one of three available ride modes. These modes

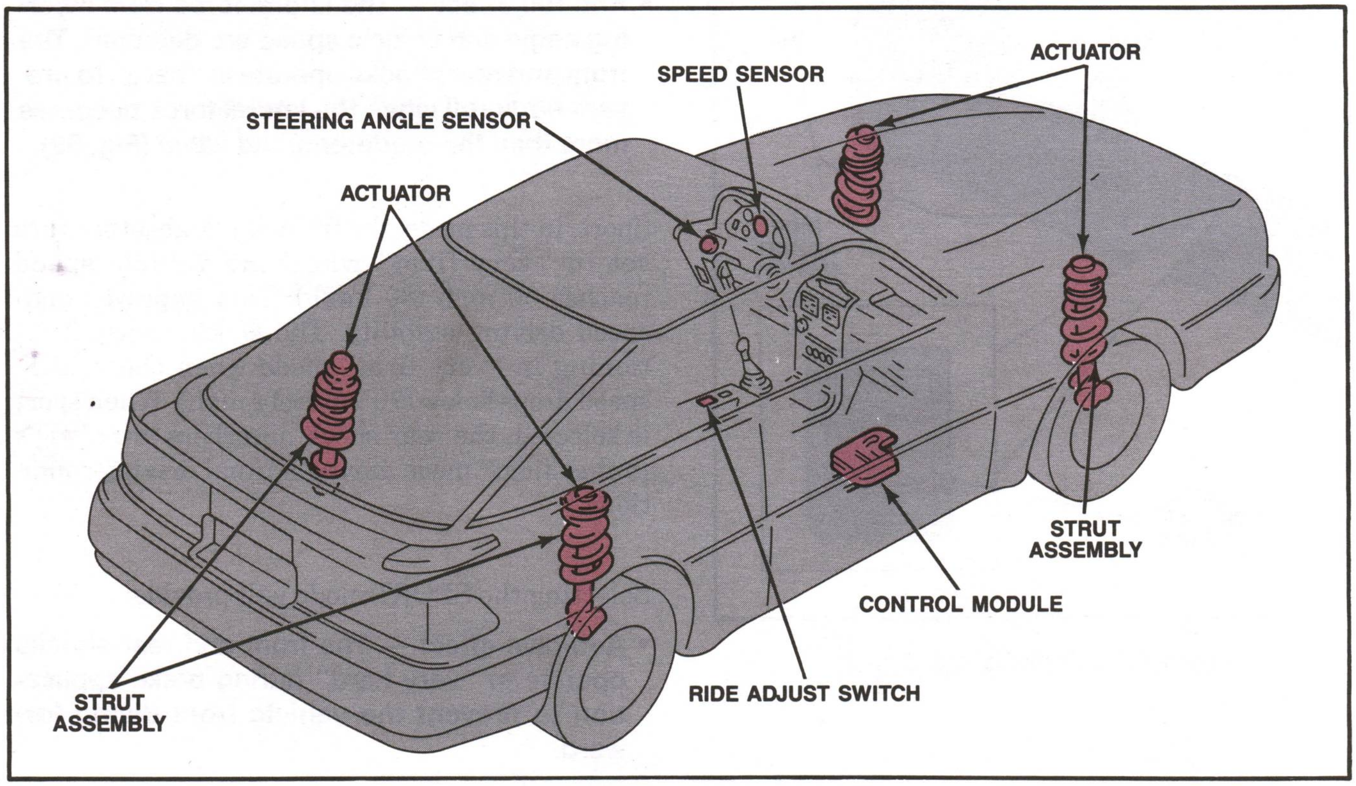


Figure 67 — Probe GT — Programmed Ride Control System

select various combinations of soft, firm and very firm damping of the front and rear strut assemblies. The mode selection is based on driving conditions and the driver's selection of ride mode. The ride control system also functions to suppress the occurrence of body roll, diving, and squatting during cornering, braking and sudden (hard) acceleration. The components incorporated into the Probe Programmed Ride Control system include (Fig. 67):

- **Ride Control Switch — Located on the center console and used by the driver to select desired ride adjust modes of operation.**
- **Mode Indicator Lamp — Incorporated into the ride control switch and used to indicate to the driver the current ride control mode of operation.**
- **Control Module — Located under the passenger's seat, this device receives the input from the sensors and is used to switch the ride control modes based on driver input at the ride adjust switch and sensor input.**
- **Speed Sensor — located within the cluster as an integral part of the speedometer subassembly and used by the control module for determination of vehicle speed.**
- **Steering Wheel Rotation Sensor — Located within the steering column and used by the control module for determination of lateral forces acting on the vehicle under normal driving conditions.**
- **Actuator Assemblies — Located at the top of each strut assembly, these devices are used to change the damping characteristics of the shock absorber within each strut assembly.**

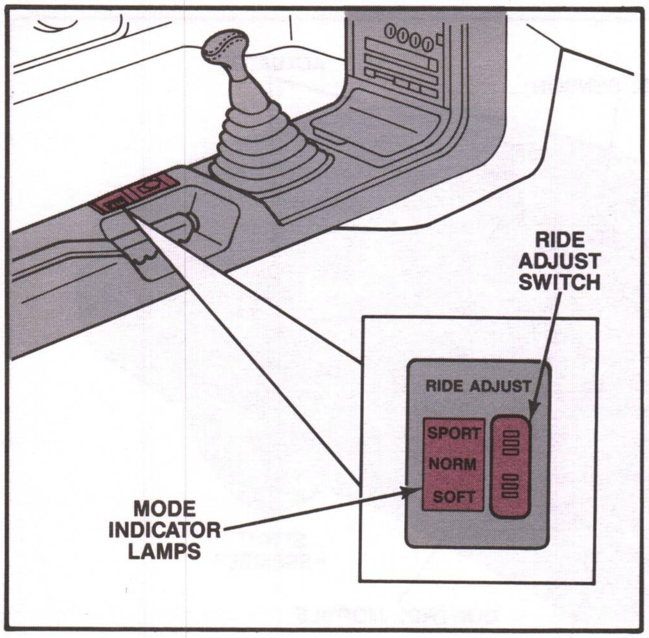


Figure 68 — Ride Control Switch

System Operation

System operation is based on the position of the ride control switch. This switch is located on the floor console to the right of the driver's seat (Fig. 68).

The switch offers the following three settings:

Normal: Under normal mode, the front shock absorbers are set in "hard" when vehicle speed reaches 80 km/h (50 mph). This improves high speed driving stability. When vehicle speed drops below 70 km/h (44 mph) the shocks are automatically set to soft. the rear shock absorbers are always in the "soft mode during normal driving conditions.

Selecting the NORMAL mode will provide:

- **Anti-dive effect — The front and rear shocks operate in "hard" during brake application to prevent the vehicle from diving forward.**
- **Anti-squat effect — The front and rear shocks operate in "hard" during sudden (hard) acceleration to prevent the vehicle from momentarily squatting.**
- **Anti-roll effect — The lateral force from steering angle and vehicle speed are detected. The front and rear shocks operate in "hard" to prevent body roll when the lateral force becomes more than the predetermined value (Fig. 69).**

Sport: In this mode, the front shock absorbers are set in "very firm" when the vehicle speed reaches 50 mph (80 km/h). This improves high speed driving stability. The shocks cease functioning in "very firm" mode when the vehicle speed drops below (70 km/h (44 mph). When sport is selected, the rear shock absorbers are always in the "firm" mode during normal driving conditions.

Selecting the SPORT mode will provide:

- **Anti-dive effect — The front and rear shocks operate in "very hard" during brake application to prevent the vehicle from diving forward.**
- **Anti-squat effect — The front and rear shocks operate in "very hard" during sudden (hard) acceleration to prevent the vehicle from momentarily squatting.**
- **Anti-roll effect — The lateral force from steering angle and vehicle speed are detected. The front and rear shocks operate in "very hard" to prevent body roll when the lateral force becomes more than the predetermined value (Fig. 69).**

Soft: In this mode, the shock absorbers at each wheel are always in the "soft" mode of operation, providing a milder, plush ride (Fig. 69)

Green indicator lamps are incorporated into the ride control switch to indicate the current mode of suspension operation.

Continental Air Suspension System

The Continental air suspension system was originally introduced in the 1988 model year. This system incorporates an air suspension system with the features of automatic ride control into

PRC Switch Position	SOFT		NORM		SPORT	
Actuator	Front	Rear	Front	Rear	Front	Rear
Vehicle Condition						
Below 50 mph (80 km/h) Straight Ahead	SOFT	SOFT	SOFT	SOFT	HARD	HARD
Above 50 mmph (80 km/h) Straight Ahead	SOFT	SOFT	HARD	SOFT	VERY HARD	HARD
Hard Cornering	SOFT	SOFT	HARD	HARD	VERY HARD	VERY HARD
Abrupt Acceleration (Read Note)	SOFT	SOFT	HARD	HARD	VERY HARD	VERY HARD
Hard Braking (Read Note)	SOFT	SOFT	HARD	HARD	VERY HARD	VERY HARD
NOTE: The PRC System calculates these criteria by the change in vehicle speed and steering angle.						

Figure 69 — Programmed Ride Control Actuator Position Chart

one driver-oriented and technologically advanced suspension system (Fig. 70). the air leveling subsystem maintains the vehicle at the proper level under varying conditions of vehicle load. The ride control subsystem switches the shock absorbers between firm and soft calibrations in response to inputs from sensors located at strategic positions on the vehicle. This helps to improve vehicle handling performance during turning maneuvers, road undulations, and braking.

System Description

The Air Suspension System includes the following major components:

- **Variable rate air springs which are integral with the struts at each corner of the vehicle.**
- **Ride height control that utilizes one rear and two front height sensors to maintain the vehicle at the proper ride height.**

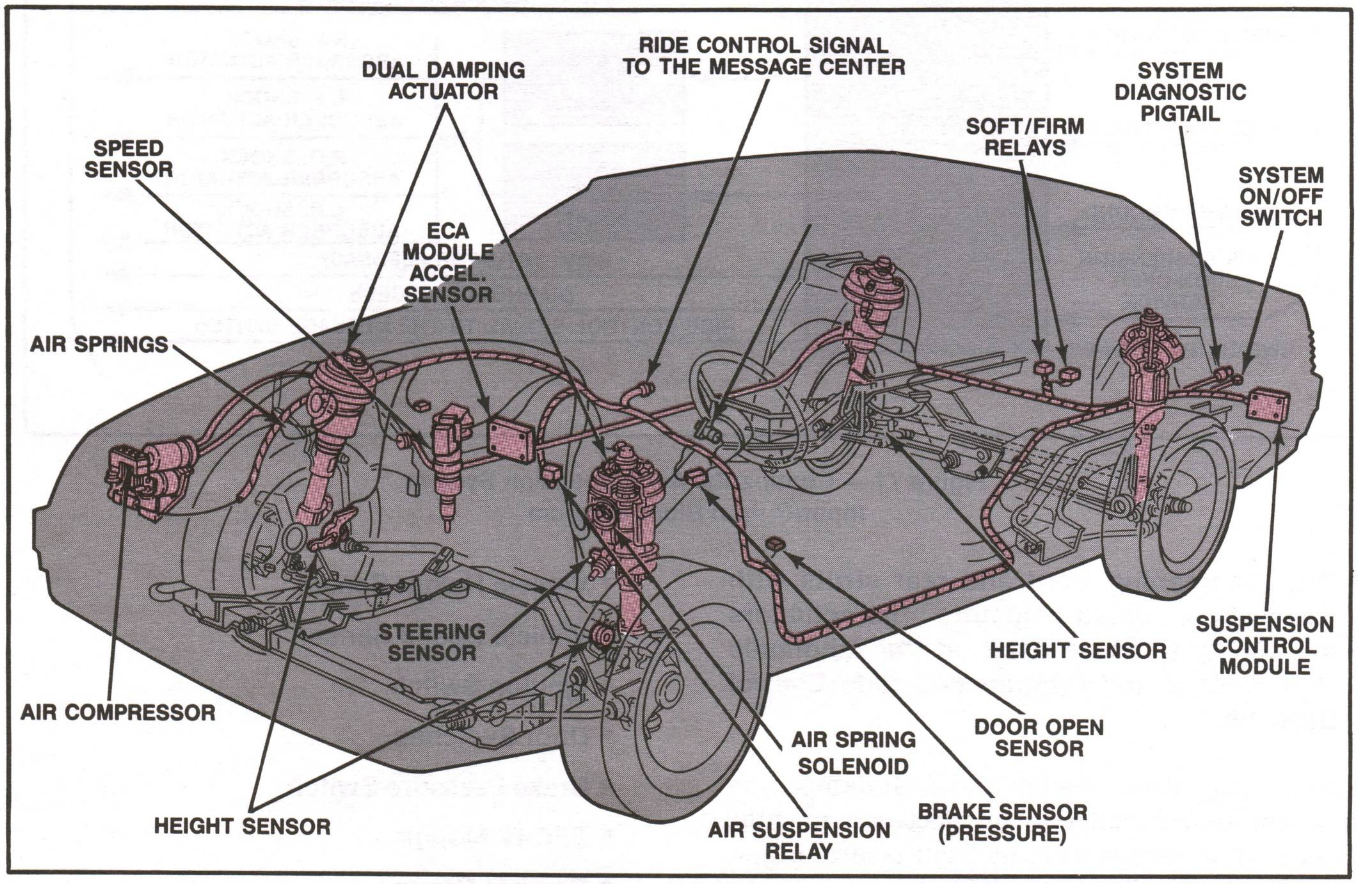

RIDE CONTROL SIGNAL TO THE MESSAGE CENTER
DUAL DAMPING ACTUATOR
SYSTEM DIAGNOSTIC PIGTAIL
SOFT/FIRM RELAYS
SPEED SENSOR
SYSTEM ON/OFF SWITCH
ECA MODULE ACCEL. SENSOR
AIR SPRINGS
STEERING SENSOR
HEIGHT SENSOR
SUSPENSION CONTROL MODULE
AIR COMPRESSOR
DOOR OPEN SENSOR
AIR SPRING SOLENOID
BRAKE SENSOR (PRESSURE)
HEIGHT SENSOR
AIR SUSPENSION RELAY

Figure 70 — Continental Air Suspension System

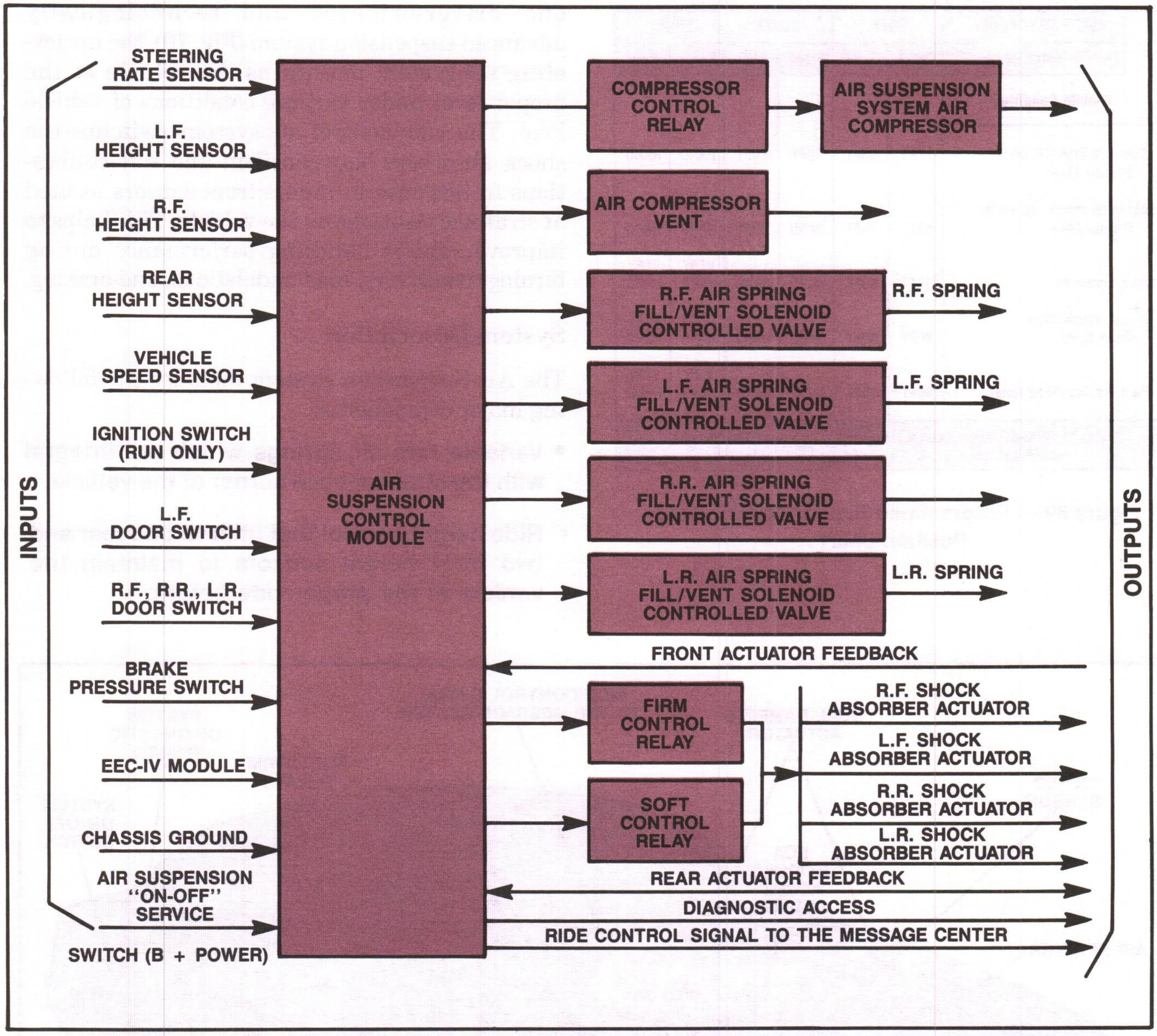

INPUTS
STEERING RATE SENSOR
L.F. HEIGHT SENSOR
R.F. HEIGHT SENSOR
REAR HEIGHT SENSOR
VEHICLE SPEED SENSOR
IGNITION SWITCH (RUN ONLY)
L.F. DOOR SWITCH
R.F., R.R., L.R. DOOR SWITCH
BRAKE PRESSURE SWITCH
EEC-IV MODULE
CHASSIS GROUND
AIR SUSPENSION "ON-OFF" SERVICE
SWITCH (B + POWER)
AIR SUSPENSION CONTROL MODULE
COMPRESSOR CONTROL RELAY
AIR SUSPENSION SYSTEM AIR COMPRESSOR
AIR COMPRESSOR VENT
R.F. AIR SPRING FILL/VENT SOLENOID CONTROLLED VALVE
R.F. SPRING
L.F. AIR SPRING FILL/VENT SOLENOID CONTROLLED VALVE
L.F. SPRING
R.R. AIR SPRING FILL/VENT SOLENOID CONTROLLED VALVE
L.R. AIR SPRING FILL/VENT SOLENOID CONTROLLED VALVE
L.R. SPRING
FRONT ACTUATOR FEEDBACK
FIRM CONTROL RELAY
SOFT CONTROL RELAY
R.F. SHOCK ABSORBER ACTUATOR
L.F. SHOCK ABSORBER ACTUATOR
R.R. SHOCK ABSORBER ACTUATOR
L.R. SHOCK ABSORBER ACTUATOR
REAR ACTUATOR FEEDBACK
DIAGNOSTIC ACCESS
RIDE CONTROL SIGNAL TO THE MESSAGE CENTER
OUTPUTS

Figure 71 — Continental Air Suspension System Input/Output Block Diagram

- **Dual dampening front and rear struts with externally mounted actuators. The actuators are similar to those used on the Automatic Ride Control and Programmed Ride Control Systems.**

The air suspension system and dual dampening function are controlled by an electronic module. This module receives inputs from several different sources (Fig. 71). These include:

- **Steering Rate Sensor**
- **Vehicle Height Sensor**
- **Vehicle Speed Sensor**
- **Ignition Switch**
- **Door Switches**
- **Brake Pressure Switch**
- **EEC-IV Module**
- **Chassis Ground**
- **Air Suspension On/Off Switch**

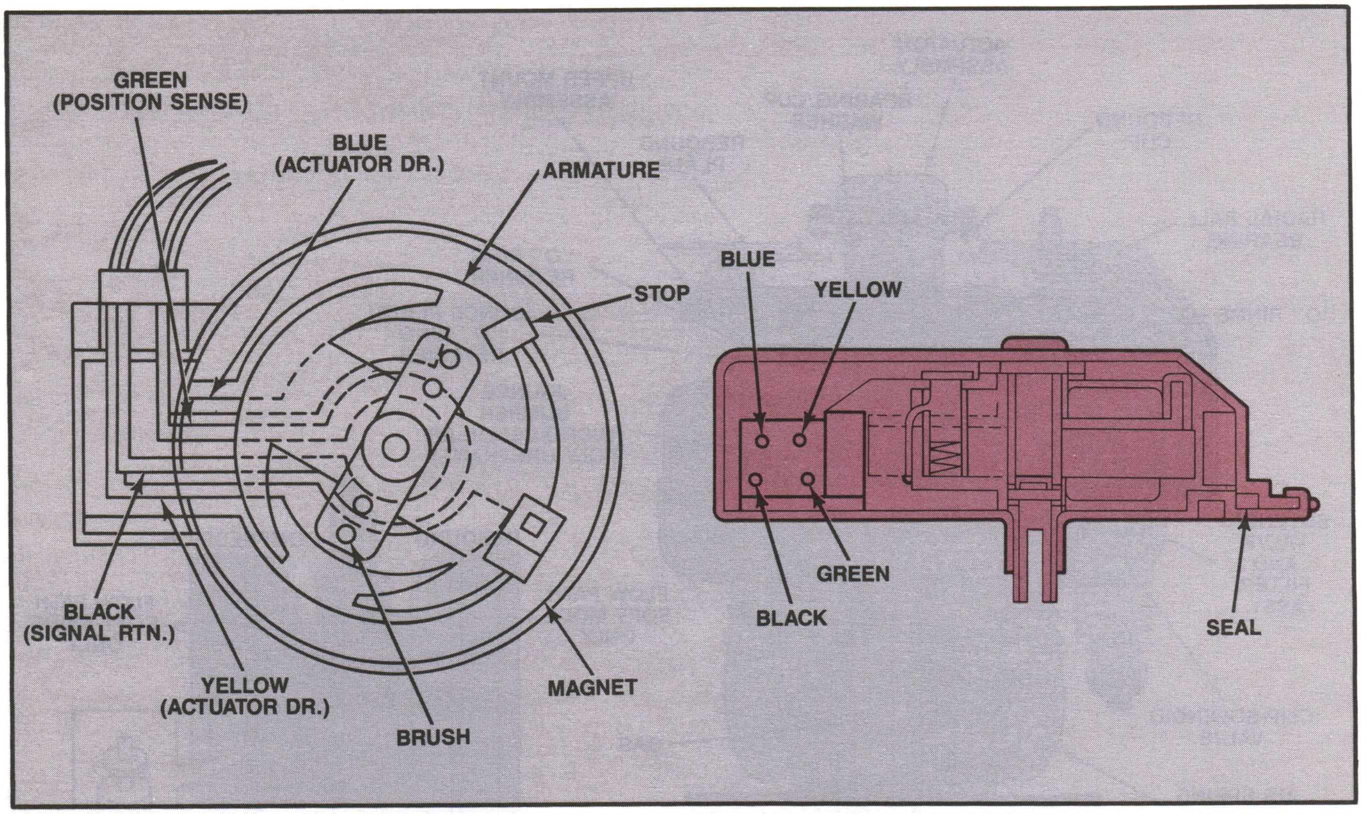


Figure 72 — Actuating Device

Several of the input devices are similar to those already discussed on the Turbo Coupe and Super Coupe/XR7 descriptions so they will not be reexamined on the Continental. These include the speed sensor, steering sensor, brake sensor, and EEC-IV module.

Air Spring and Strut Assembly

The front and rear suspension systems on the Continental utilize MacPherson strut assemblies with integral air springs and two-stage dampening mechanisms. The two-stage dampening is achieved by varying the effective piston orifice area with an externally mounted electronic rotary actuator, similar to those used in the other ride control system (Fig. 72).

The front struts are mounted to the body through a precision ball bearing and rubber mount system (Fig. 73). The ball bearings provide a very smooth and highly durable pivot point for the strut/wheel assembly. The oversize rubber mounting provides for maximum impact and noise isolation.

The rear struts (Fig. 74) use a dual path mount which separates the strut and air spring mounting surfaces to provide for maximum isolation.

Both the front and rear strut assemblies show the flow path for oil during the soft mode. Note that there are two orifices from which the oil is allowed to escape in the soft mode. When the shock portion of the strut is shifted into the firm mode by the control module, these orifices are closed, reducing the amount of oil venting, and increasing the pressure within the shock.

Air Suspension Control Module

The Continental uses a control module (Fig. 75) which combines the air suspension and variable damping systems. Because the module controls all actuators, relays and solenoid valves by supplying positive battery power, a short circuit protection capability has been designed into the module.

The control module operates in both an ignition ON and ignition OFF mode.

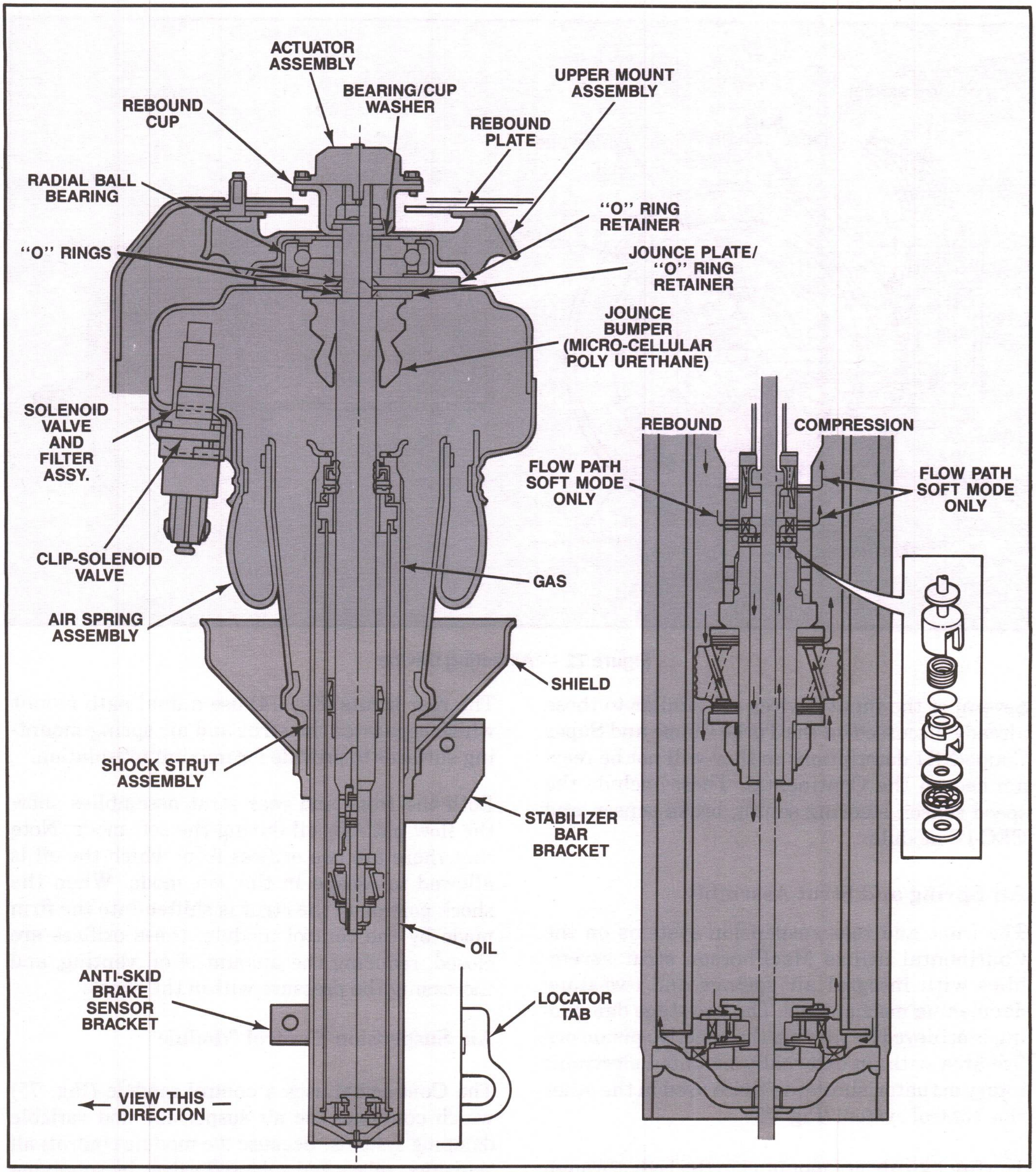

ACTUATOR ASSEMBLY
BEARING/CUP WASHER
UPPER MOUNT ASSEMBLY
REBOUND CUP
REBOUND PLATE
RADIAL BALL BEARING
"O" RING RETAINER
"O" RINGS
JOUNCE PLATE/ "O" RING RETAINER
JOUNCE BUMPER (MICRO-CELLULAR POLY URETHANE)
SOLENOID VALVE AND FILTER ASSY.
REBOUND
COMPRESSION
FLOW PATH SOFT MODE ONLY
FLOW PATH SOFT MODE ONLY
CLIP-SOLENOID VALVE
GAS
AIR SPRING ASSEMBLY
SHIELD
SHOCK STRUT ASSEMBLY
STABILIZER BAR BRACKET
OIL
ANTI-SKID BRAKE SENSOR BRACKET
LOCATOR TAB
VIEW THIS DIRECTION

Figure 73 — Front Strut Assembly

The ignition ON mode performs vehicle leveling and variable damping control.

Variable damping control is executed when a handling or road undulation event occurs. Handling events are detected by processing information from either the steering sensor, brake sensor, or acceleration input signal passed from the EEC-IV module. The vehicle speed sensor also supplies important

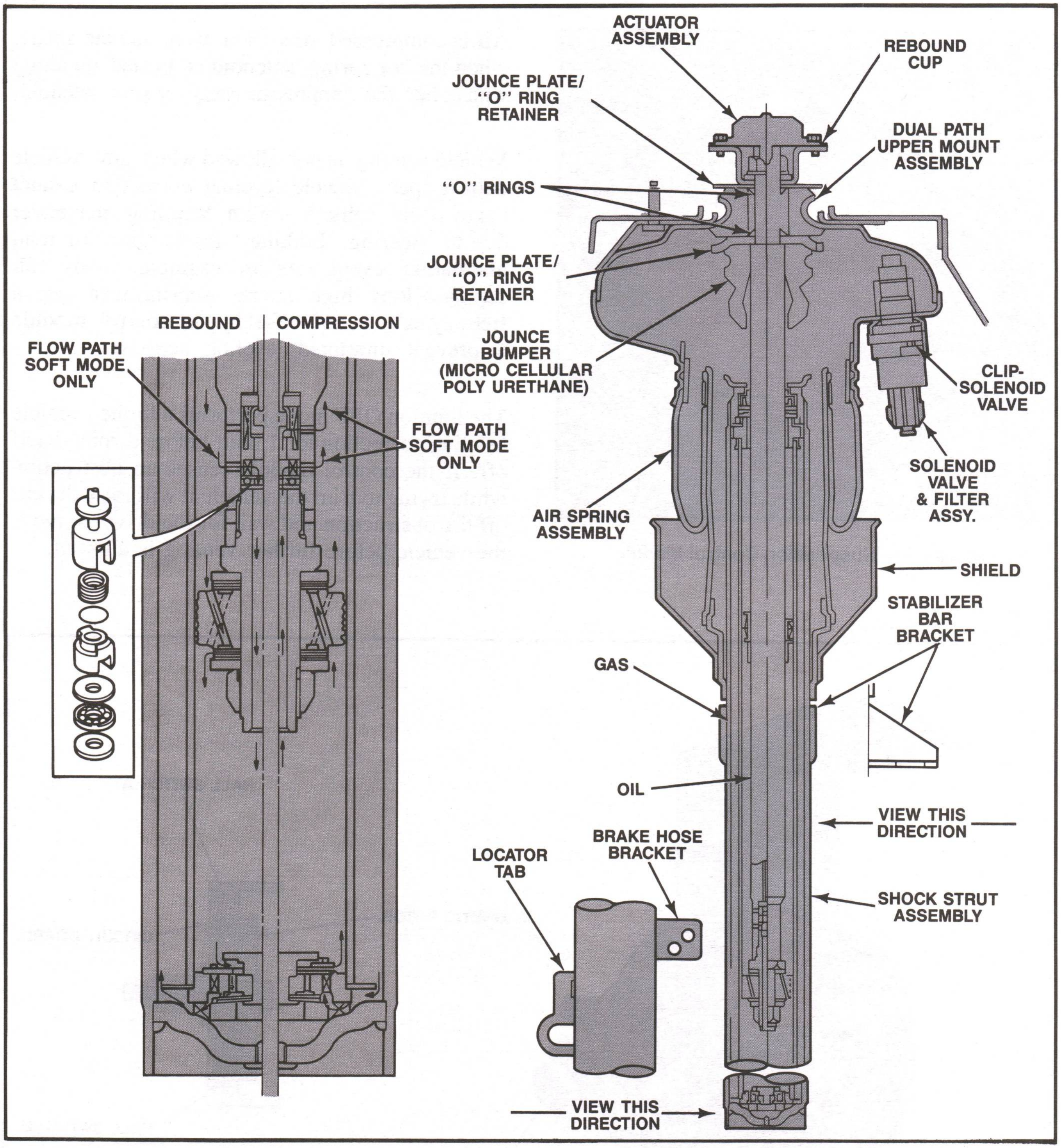

ACTUATOR ASSEMBLY
REBOUND CUP
JOUNCE PLATE/ "O" RING RETAINER
DUAL PATH UPPER MOUNT ASSEMBLY
"O" RINGS
JOUNCE PLATE/ "O" RING RETAINER
REBOUND
COMPRESSION
FLOW PATH SOFT MODE ONLY
JOUNCE BUMPER (MICRO CELLULAR POLY URETHANE)
CLIP-SOLENOID VALVE
FLOW PATH SOFT MODE ONLY
SOLENOID VALVE & FILTER ASSY.
AIR SPRING ASSEMBLY
SHIELD
STABILIZER BAR BRACKET
GAS
OIL
VIEW THIS DIRECTION
BRAKE HOSE BRACKET
LOCATOR TAB
SHOCK STRUT ASSEMBLY
VIEW THIS DIRECTION

Figure 74 — Rear Strut Assembly

information into the handling strategy. A road undulation event is like a road dip and is detected by processing information from the height sensor.

Vehicle leveling is accomplished in the following manner:

The control module gathers vehicle height information by monitoring the three vehicle height sensors. A software strategy then determines when a leveling correction is needed. The system adjusts vehicle height by either compressing or venting the air spring(s) to the trim position.

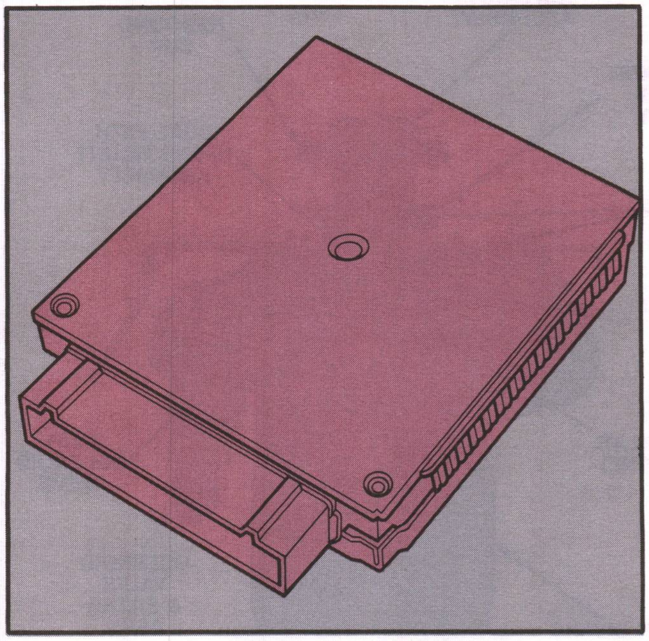


Figure 75 — Suspension Control Module

Air is compressed or vented from the air spring when the air spring solenoid is turned on along with either the compressor relay or vent solenoid.

Vehicle venting is not allowed when any vehicle door is open. Vehicle leveling correction cannot begin if the vehicle is in a handling maneuver due to steering, braking, acceleration or road undulation event. As an example: body roll during a long high lateral steering turn (eg. a freeway exit) is not offset by the control module to prevent unwanted leveling actions.

The ignition OFF mode performs a limited vehicle leveling correction for 1 hour before turning itself off. If the control module senses an obstruction while trying to trim the vehicle it will raise the car off the obstruction and wait for the driver to move the vehicle before further venting is allowed.

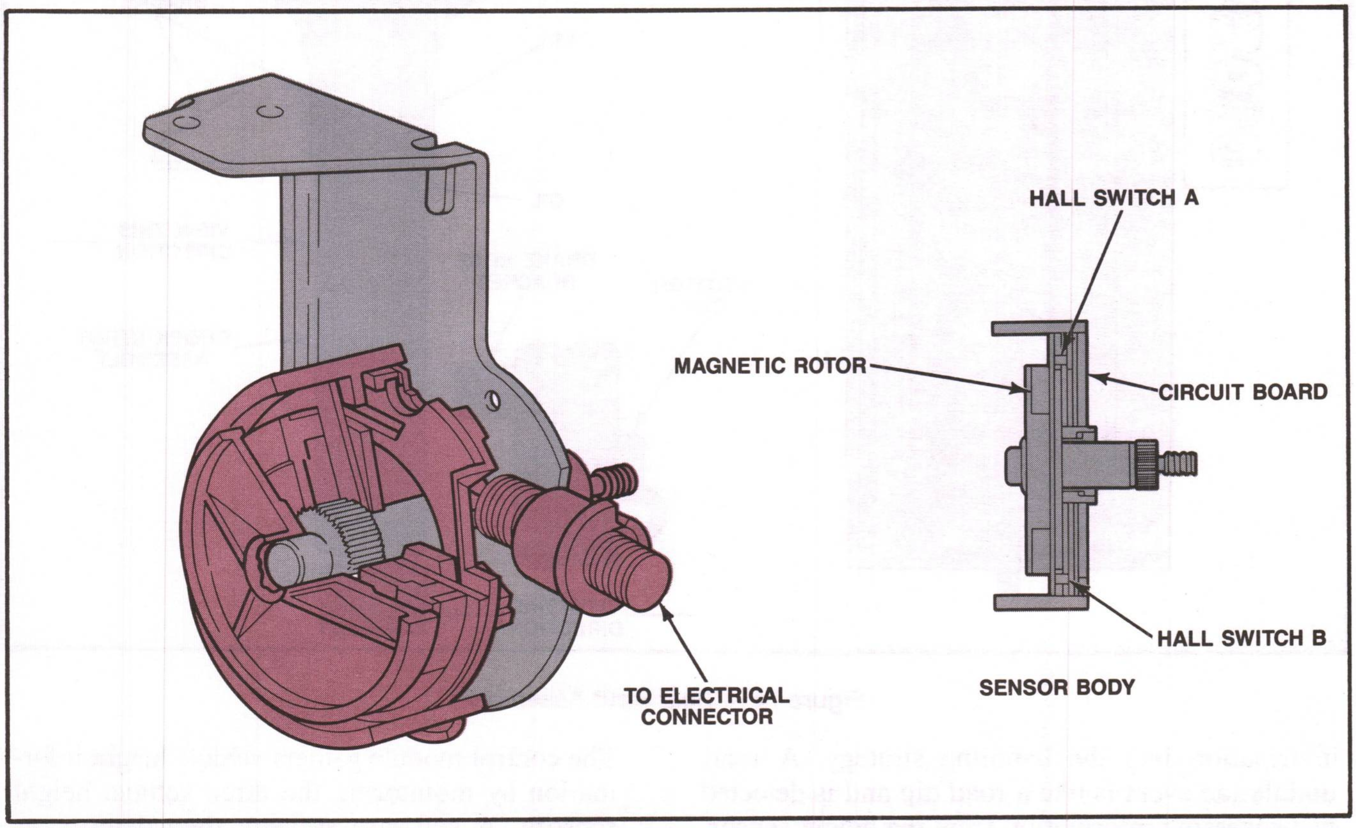


Figure 76 — Electronic Rotary Height Sensor

Electronic Height Sensor

The height sensor used on the Continental is a special rotary style design introduced with this system in 1988. It is equipped with an internal Hall effect device to determine ride height (Fig. 76). These sensors will indicate conditions of Above Trim, Trim and Below Trim to the control module.

Counter-Balancing Torsion Springs

Although it is not a part of the electronics, the counter-balancing torsion springs are worth mentioning because they are an engineering innovation. These springs fit between the MacPherson strut and the lower suspension arms (Fig. 77). They are designed to produce an outward force on the strut that will offset the twisting forces that are induced by the road on the wheel. The effect is to significantly reduce the strut sideload/twisting. The addition of these springs frees the suspension from this additional stress. Freeing the suspension from this stress allows the vehicle to achieve a luxury car ride and plushness that is consistent with a world-class luxury car image. The use of these springs on the Continental was the first known application of its type in the world market.

System Operation

Unlike the Automatic and Programmed Ride Control Systems, there is no ride control switch to allow driver control of the strut dampening function in the Air Suspension System. All system operations are automatically performed. The system is designed specifically to react to undue driving conditions to allow greater control and stability for the driver. This greater control and stability would not be possible with the typical plush suspension that is expected with a Continental.

Road Undulation

The road undulation function uses the rotary height sensors to measure road wheel speed and travel (up-and-down movement). If the average wheel speed over a specified distance is above a predetermined level, the shocks are switched to the firm position. This function has been designed to eliminate "grounding out" of the subframe when traveling over railroad crossings or similar types of road surfaces.

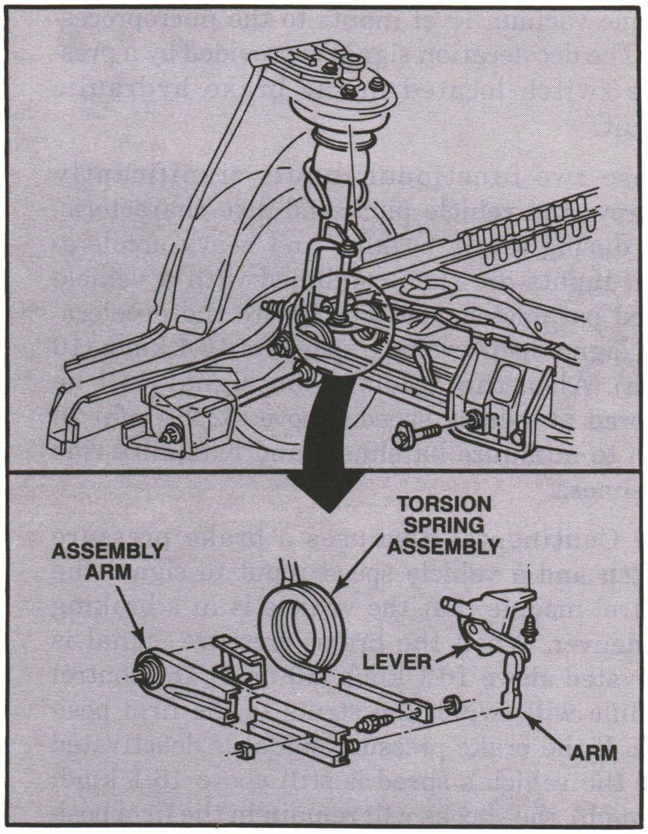


Figure 77 — Continental Rear Suspension Counter-Balancing Torsion Springs

This function is utilized at vehicle speeds greater than 10 mph. The control module will sample the height sensors every 4 milliseconds to determine if the rate of suspension travel change is sufficient enough to require a firm shock setting. The struts will remain in the firm position until the vehicle's speed drops below 10 MPH and/or the rate of change in the suspension movement is below the control module's design limit. This is the first known production application of this type of suspension system control.

Acceleration and Deceleration

The shock dampening is also switched to the firm position if the acceleration or deceleration values exceed predetermined limits. The acceleration signal is provided by the EEC-IV module and is a combination of throttle position and/or engine vacuum level inputs to the microprocessor. The deceleration signal is provided by a pressure switch located in the brake hydraulic circuit.

These two functional inputs significantly improve the vehicle pitch and dive characteristics during severe braking and heavy acceleration. Inputs are then combined with a vehicle speed parameter that will ignore the deceleration signal below vehicle speeds of 16.1 km/h (10 mph). Also, the acceleration signal will be ignored at vehicle speeds above (32.2 km/h) 20 mph to minimize harshness and maximize ride plushness.

The Continental also uses a brake pressure switch and a vehicle speed input to signal the control module that the vehicle is in a braking maneuver. When the brake pressure signal is activated above 16.1 km/h (10 mph), the control module will switch the struts to the firm position. If the brake pressure signal is deactivated and the vehicle's speed is still above 16.1 km/h (10 mph), the shocks will remain in the firm position an additional 0.5 second before switching back to the soft position. If the brake pressure signal remains activated after the vehicle's speed drops below 16.1 km/h (10 mph), the struts will remain in the firm position for only 1.0 seconds.

Mark VII Air Suspension System

The final suspension system that will be discussed is the Air Suspension System used on the Mark VII. This system has been used on the Mark VII since its introduction in 1984 and is also used on the 1984 through 1987 Continental.

System Description

The Mark VII Air Suspension System features four air springs, made of rubber and plastic. These springs support the vehicle load at the front and rear wheels. The front air springs are mounted to a spring pocket in the crossmember and on the lower suspension arms, in a way similar to a conventional front spring system. The rear air springs are mounted ahead of the rear axle outside the body subframe side members and on the lower rear suspension arms in a way similar to a conventional rear spring system.

A single-cylinder piston-type, electrically operated air compressor, mounted on the left fender apron, supplies the air pressure for operating the system. A regenerative type dryer is attached to the compressor manifold. All air flow during compression or venting passes through the dryer. A vent solenoid, located on the compressor manifold, controls venting of air from the system.

The air flow to the entire system is controlled by the interaction of the air compressor, solenoids, height sensors and control module. All air operated parts of the system are connected by nylon tubing.

Vehicle height is controlled by the interaction of the air compressor, solenoids, height sensors and the control module.

The major components of the system can be seen in the following illustration (Fig. 78). The following statements provide a description and explanation of component function.

1. Compressor Relay

- **Opens and closes high amperage battery feed circuit to the compressor**
- **Module operates compressor by providing relay ground circuit**

2. Air Compressor

- **Single-cylinder, motor-driven air compressor**
- **Regenerative air dryer removes moisture from air entering system**
- **Air exhausted during lowering of vehicle removes moisture from dryer**
- **Four air lines, one to each spring, are covered by a protective cap**

3. Service Indicator Light

- **Module monitors system operation; when problem is detected, module switches on light**
- **Light alerts driver to system malfunction**
- **During self-test, light flashes test number and helps isolate system malfunctions**

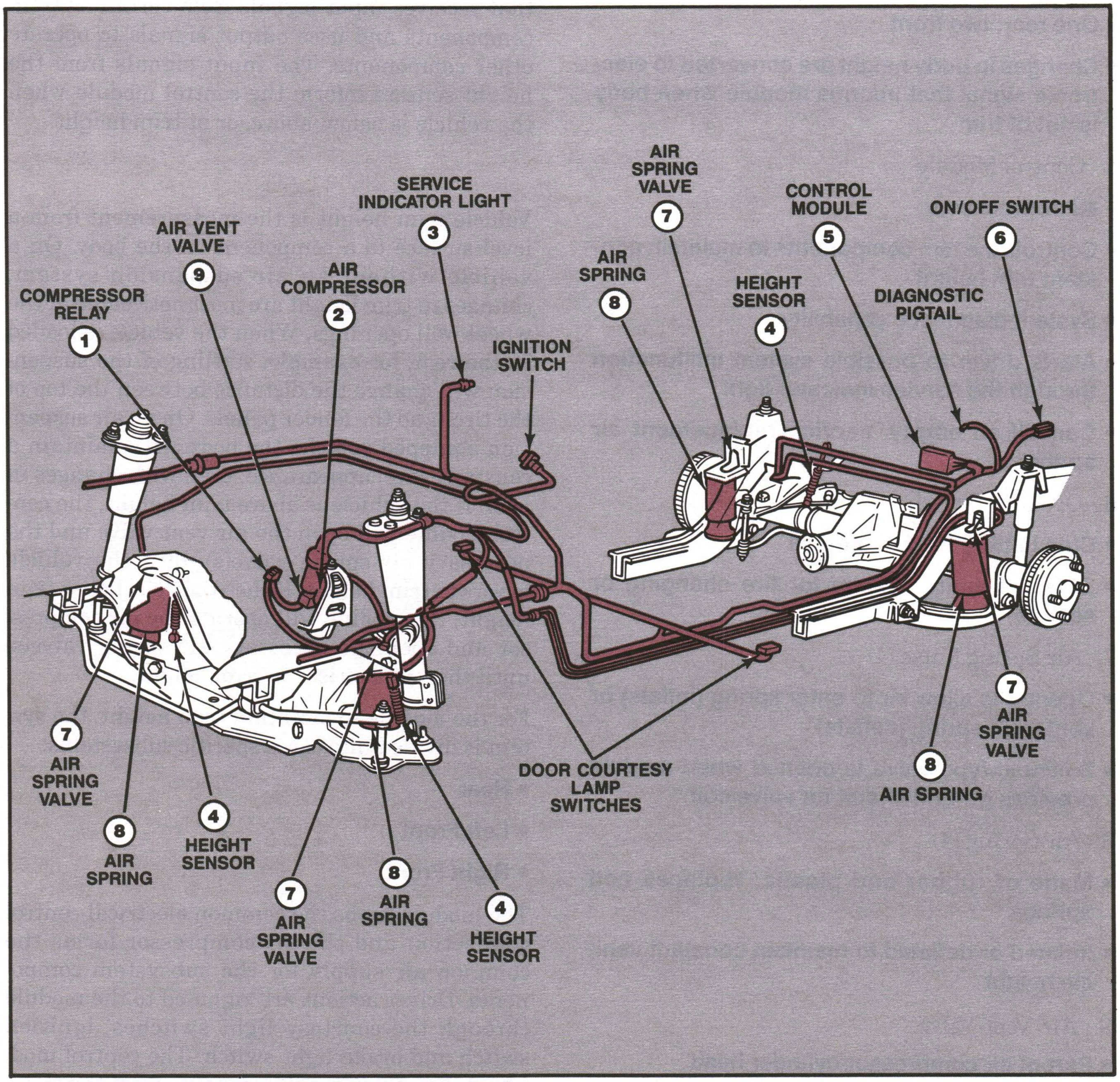

AIR SPRING VALVE
⑦
SERVICE INDICATOR LIGHT
③
CONTROL MODULE
⑤
ON/OFF SWITCH
⑥
AIR VENT VALVE
⑨
AIR COMPRESSOR
②
AIR SPRING
⑧
HEIGHT SENSOR
④
DIAGNOSTIC PIGTAIL
COMPRESSOR RELAY
①
IGNITION SWITCH
⑦
AIR SPRING VALVE
⑦
AIR SPRING VALVE
⑧
AIR SPRING
④
HEIGHT SENSOR
DOOR COURTESY LAMP SWITCHES
⑧
AIR SPRING
⑦
AIR SPRING VALVE
⑧
AIR SPRING
④
HEIGHT SENSOR

Figure 78 — Air Suspension System Components

4. Height Sensor

- **Attached to body and suspension arms**
- **One rear, two front**
- **Changes in body height are converted to electronic signal that informs module when body is out of trim**

5. Control Module

- **Microprocessor**
- **Controls system components to maintain constant trim height**
- **System diagnostic capability**
- **Alerts driver to possible system malfunction through the service indicator light**
- **Can fill an empty, service replacement air spring**

6. ON/OFF Switch

- **Cuts battery feed to module**
- **Disables entire system for tire changing or service**

7. Air Spring Valve (4)

- **Opened to allow air to enter spring (inflate) or vent from spring (deflate)**
- **Solenoid-type valve is opened when module provides ground circuit for valve coil**

8. Air Spring (4)

- **Made of rubber and plastic, replaces coil springs**
- **Inflated or deflated to maintain constant vehicle height**

9. Air Vent Valve

- **Part of air compressor cylinder head**
- **Opens only when module wants to lower vehicle**
- **Solenoid-type valve is opened when module provides ground circuit for valve coil**

Control Module and On/Off Switch

The control module is a small microprocessor that receives input signals from certain system components and uses output signals to operate other components. The input signals from the height sensors inform the control module when the vehicle is below, above, or at trim height.

Vehicle trim height is the measurement from a level surface to a component on the body. On a vehicle without an air suspension system, changes in trim height are most noticeable at the wheel well openings. When the vehicle is loaded in the rear, for example, settling of the suspension will change the distance between the top of the tires and the fender panels. On an air suspension equipped vehicle, the body will maintain a constant, level appearance, even with changes in load. If the vehicle is above trim height, the control module will open the air vent valve and the necessary air spring valve(s) until the vehicle lowers to trim height. If the vehicle is below trim height, the module will operate the air compressor and open the necessary air spring valve(s) until the vehicle rises to trim height.

For the module to maintain trim height, the system is divided into three specific subsystems:

- **Rear**
- **Left Front**
- **Right Front**

The module forms the common electrical control connection and the air compressor forms the common air supply for the subsystem components. Driver actions are signaled to the module through the courtesy light switches, ignition switch and brake light switch. The control module continuously monitors inputs from the three height sensors, the ignition switch, the brake and door courtesy lamp circuits. All of these inputs are used by the module to make vehicle leveling decisions.

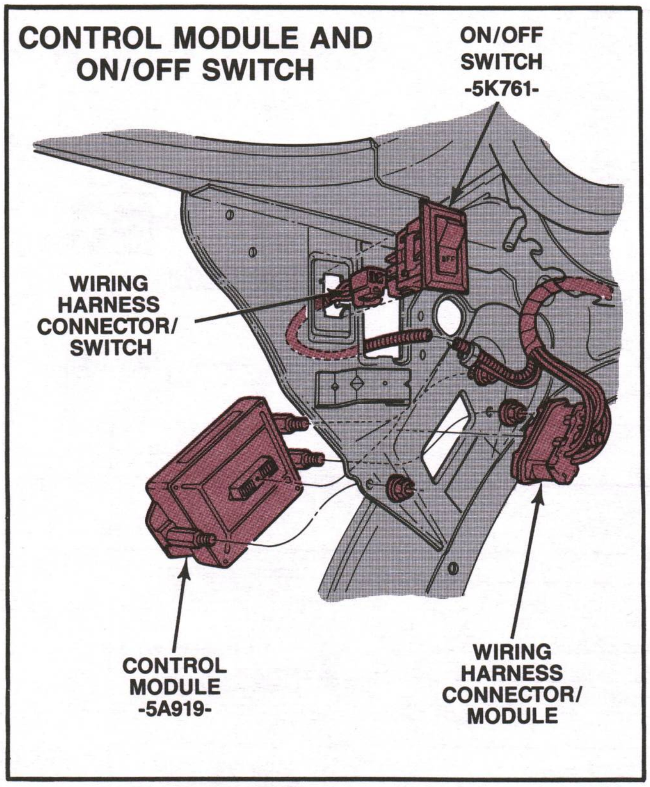

CONTROL MODULE AND ON/OFF SWITCH
ON/OFF SWITCH -5K761-
WIRING HARNESS CONNECTOR/ SWITCH
CONTROL MODULE -5A919-
WIRING HARNESS CONNECTOR/ MODULE

Figure 79 — Control Module and On/Off Switch

In addition to operating the load-leveling system, the control module has a self-diagnosis capability. While operating the system, the module compares height inputs against a time factor for trim corrections. If the module determines a sensor input is invalid, or a time factor is exceeded it will alert the driver to a system malfunction by lighting the CHECK SUSPENSION indicator lamp in the overhead console. During a service check to diagnose a malfunction, the module is entered into a 10-step diagnostic sequence that checks each subsystem and each individual component.

The module is located behind the trim panel on the left side of the trunk. This is also the general location of the system ON/OFF switch (Fig. 79). When the switch is moved to the OFF position, the battery feed circuit to the module is opened and the air suspension system is electrically disabled. Turning the switch OFF will turn the service indicator light ON whenever the ignition switch is in the RUN position.

WARNING: BE SURE THE SYSTEM CONTROL SWITCH IS IN THE OFF POSITION WHENEVER A SYSTEM COMPONENT IS BEING SERVICED. THE SWITCH MUST ALSO BE IN THE OFF POSITION PRIOR TO HOISTING, JACKING, OR TOWING THE VEHICLE.

The control module has a variety of inputs and output devices to be aware of. The inputs and outputs are shown in Figure 80.

Height Sensor

The air suspension system control module requires a vehicle height input signal. There are three conditions that can exist:

- **Above Trim Height**
- **At Trim Height**
- **Below Trim Height**

The sensor signal provides a reading that the control module translates into one of the three vehicle conditions.

In addition to vehicle height, the module requires input signals to indicate which part of the vehicle needs a height correction. One sensor, located in the front of the rear axle detects load changes in the luggage compartment and passenger rear seats. The remaining two sensors are positioned at each front wheel to detect driver and passenger seat loads.

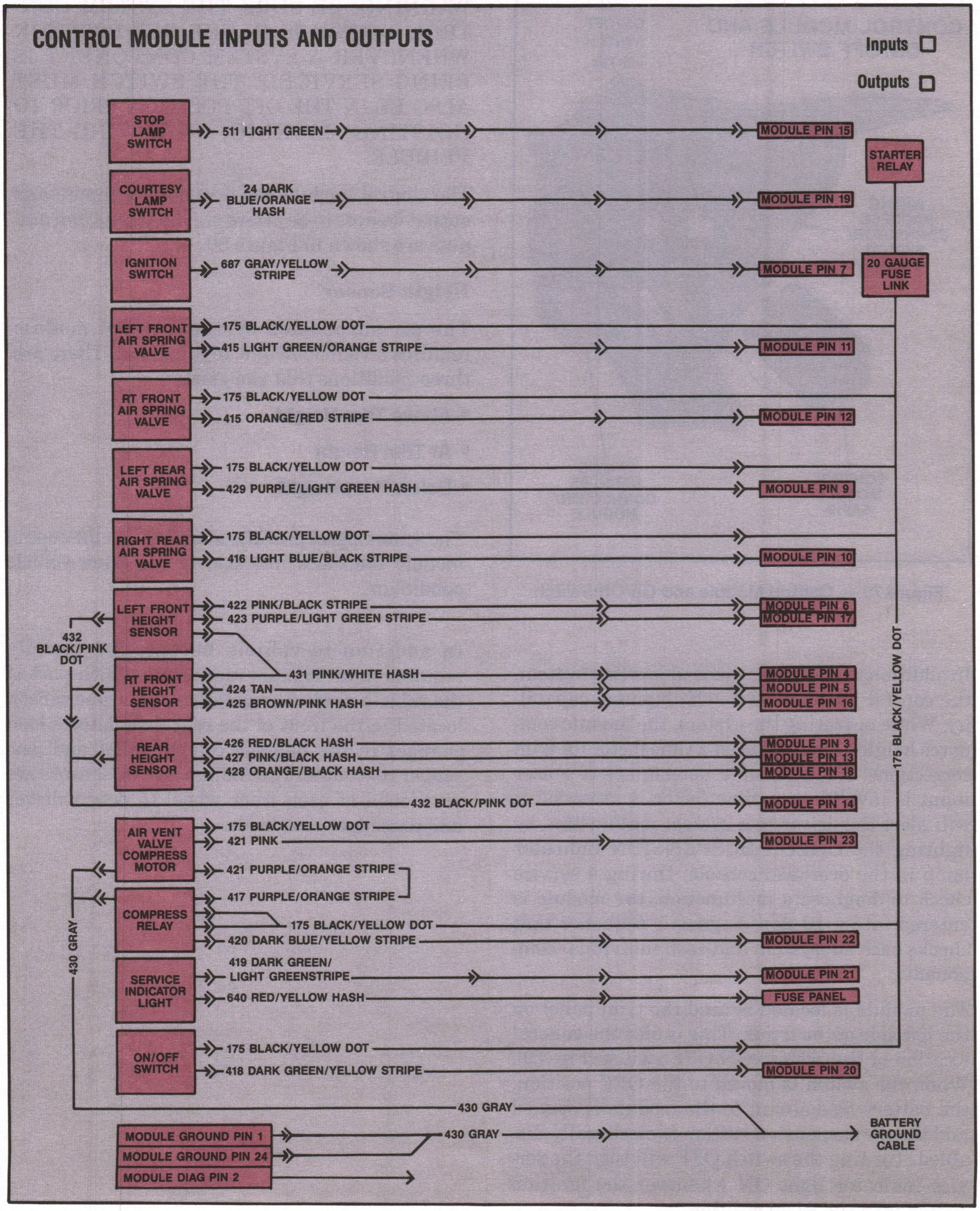

CONTROL MODULE INPUTS AND OUTPUTS
Inputs ☐
Outputs ☐
STOP LAMP SWITCH
511 LIGHT GREEN
MODULE PIN 15
STARTER RELAY
COURTESY LAMP SWITCH
24 DARK BLUE/ORANGE HASH
MODULE PIN 19
IGNITION SWITCH
687 GRAY/YELLOW STRIPE
MODULE PIN 7
20 GAUGE FUSE LINK
LEFT FRONT AIR SPRING VALVE
175 BLACK/YELLOW DOT
415 LIGHT GREEN/ORANGE STRIPE
MODULE PIN 11
RT FRONT AIR SPRING VALVE
175 BLACK/YELLOW DOT
415 ORANGE/RED STRIPE
MODULE PIN 12
LEFT REAR AIR SPRING VALVE
175 BLACK/YELLOW DOT
429 PURPLE/LIGHT GREEN HASH
MODULE PIN 9
RIGHT REAR AIR SPRING VALVE
175 BLACK/YELLOW DOT
416 LIGHT BLUE/BLACK STRIPE
MODULE PIN 10
LEFT FRONT HEIGHT SENSOR
432 BLACK/PINK DOT
422 PINK/BLACK STRIPE
423 PURPLE/LIGHT GREEN STRIPE
MODULE PIN 6
MODULE PIN 17
RT FRONT HEIGHT SENSOR
431 PINK/WHITE HASH
424 TAN
425 BROWN/PINK HASH
MODULE PIN 4
MODULE PIN 5
MODULE PIN 16
175 BLACK/YELLOW DOT
REAR HEIGHT SENSOR
426 RED/BLACK HASH
427 PINK/BLACK HASH
428 ORANGE/BLACK HASH
MODULE PIN 3
MODULE PIN 13
MODULE PIN 18
432 BLACK/PINK DOT
MODULE PIN 14
AIR VENT VALVE COMPRESS MOTOR
175 BLACK/YELLOW DOT
421 PINK
MODULE PIN 23
421 PURPLE/ORANGE STRIPE
417 PURPLE/ORANGE STRIPE
COMPRESS RELAY
175 BLACK/YELLOW DOT
420 DARK BLUE/YELLOW STRIPE
MODULE PIN 22
430 GRAY
SERVICE INDICATOR LIGHT
419 DARK GREEN/ LIGHT GREENSTRIPE
MODULE PIN 21
640 RED/YELLOW HASH
FUSE PANEL
ON/OFF SWITCH
175 BLACK/YELLOW DOT
418 DARK GREEN/YELLOW STRIPE
MODULE PIN 20
430 GRAY
MODULE GROUND PIN 1
MODULE GROUND PIN 24
MODULE DIAG PIN 2
430 GRAY
BATTERY GROUND CABLE

Figure 80 — Air Suspension System Inputs and Outputs

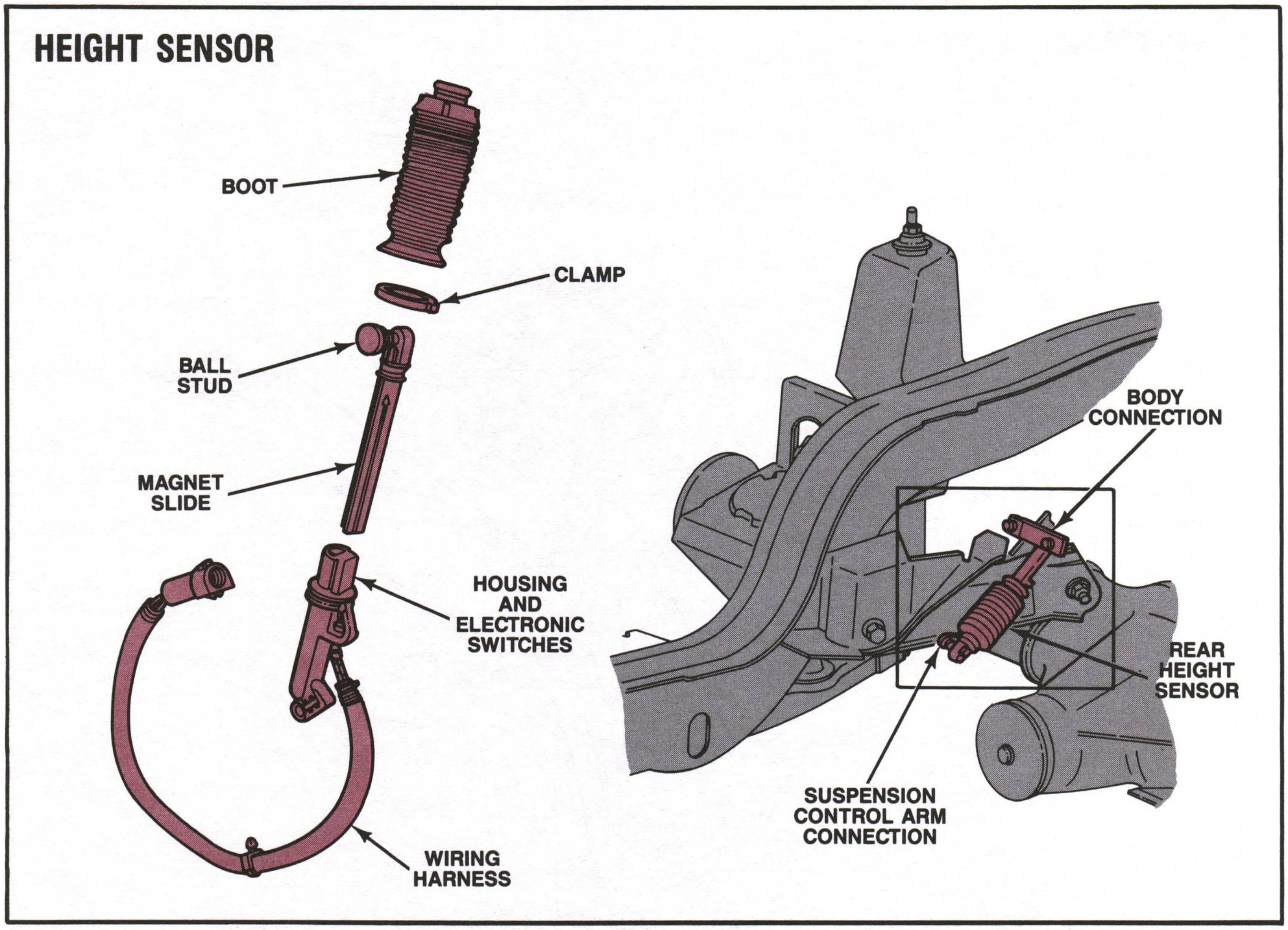


Figure 81 — Height Sensor

The sensors are attached to the body at one end, and to the suspension control arm at the other end (Fig. 81). The ends of the sensors are attached to the suspension control arms, which allows the sliding magnets contained in the sensor to move with changes in vehicle height. As the magnets move, they generate a signal to the module through two switches. These switches are small electronic circuits, and are attached to the sensor housing.

Movement of the magnets determines switch opening and closing. When the vehicle is at trim height, the switches remain closed and the module receives a trim signal. If the magnets move upward, one switch will open to indicate an above-trim condition. Downward movement of the magnets will close the above-trim switch and close the below-trim switch indicating proper trim.

The opening and closing of these electronic switches is monitored by the control module circuitry. The switches are not mechanical and no attempt should be made to visually inspect their operation. Any attempt to probe or inspect the height sensor switches can result in failure of the sensor.

Air Compressor Relay

The battery feed circuit to the air compressor motor is opened and closed by the air compressor relay. The module provides a ground circuit for the relay coil and lets the contact points carry the heavy current flow needed to operate the compressor motor. When the contacts are magnetically closed, the battery feed circuit to the compressor is completed and the motor should operate.

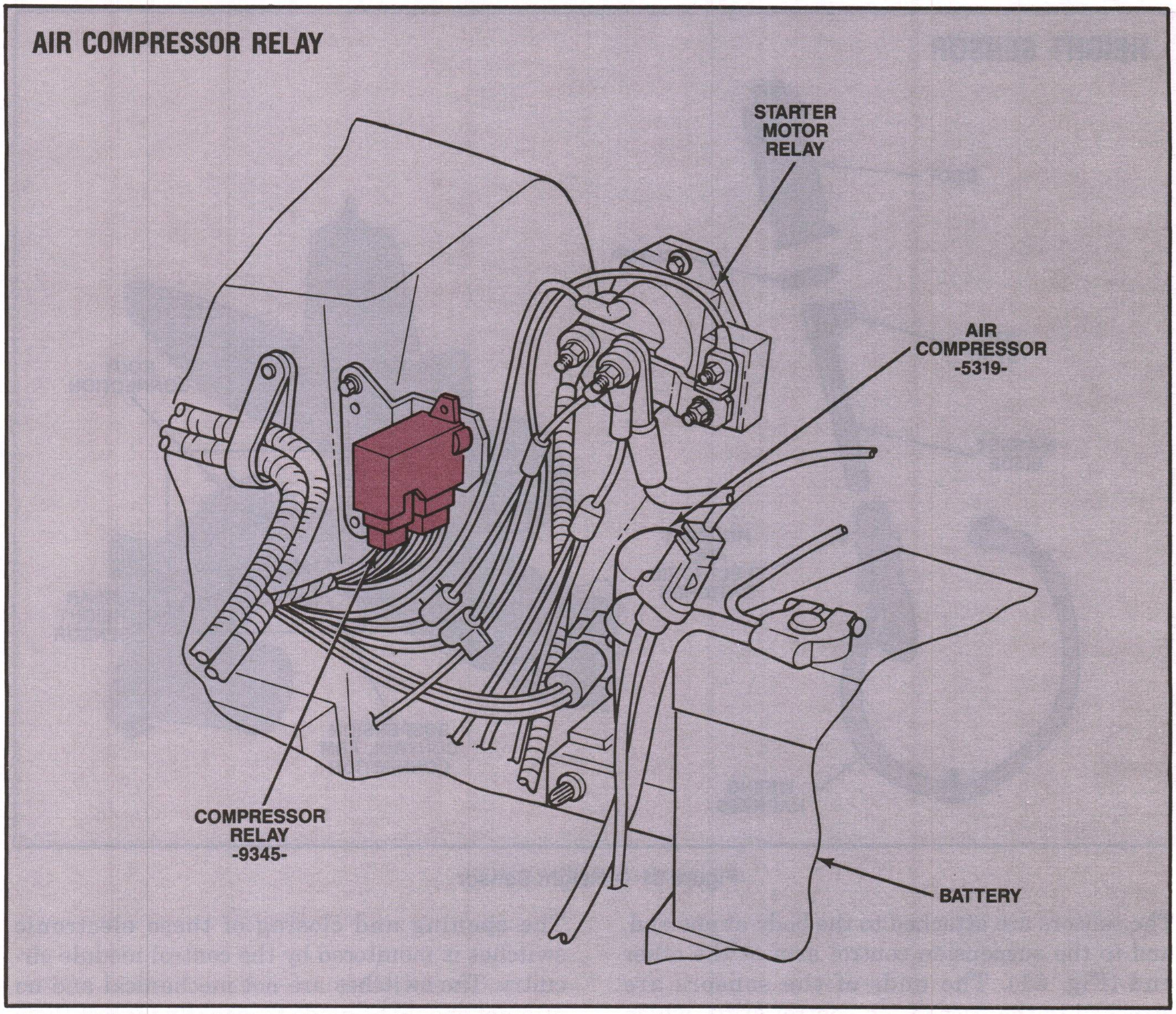

AIR COMPRESSOR RELAY
STARTER MOTOR RELAY
AIR COMPRESSOR -5319-
COMPRESSOR RELAY -9345-
BATTERY

Figure 82 — Air Compressor Relay

The compressor relay is located near the air compressor on a bracket attached to the left strut tower (Fig. 82).

Air Compressor

The pressurized air supply needed to raise the vehicle is produced by a motor driven, single-cylinder air compressor (Fig. 83), which is mounted on the left side of the engine compartment, just behind the battery.

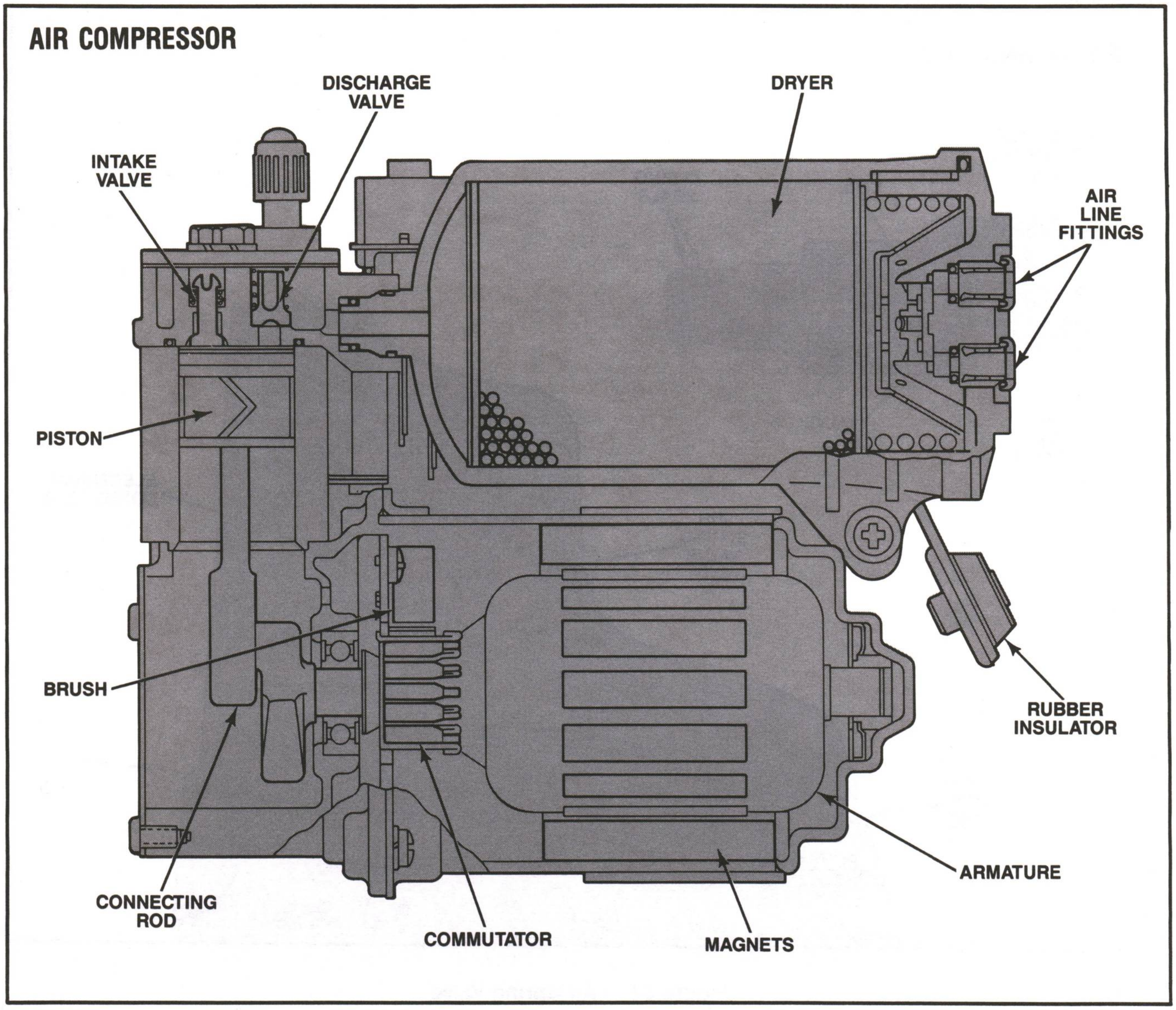

AIR COMPRESSOR
DISCHARGE VALVE
DRYER
INTAKE VALVE
AIR LINE FITTINGS
PISTON
BRUSH
RUBBER INSULATOR
ARMATURE
CONNECTING ROD
COMMUTATOR
MAGNETS

Figure 83 — Air Compressor

When the compressor is operating, the electric motor is connected to the battery feed circuit through the compressor relay. Operation of the relay, and therefore of the motor, is controlled by the module. The compressor will operate only if the height sensor signal indicates that the vehicle is below trim height and requires additional air to raise it to trim height.

Before entering the system, the pressurized air passes through a dryer containing a silica gel. Any moisture contained in the air is trapped in the gel to prevent contamination of the system. The moisture is removed from the dryer when vented air passes out of the system (regeneration) during lowering of the vehicle.

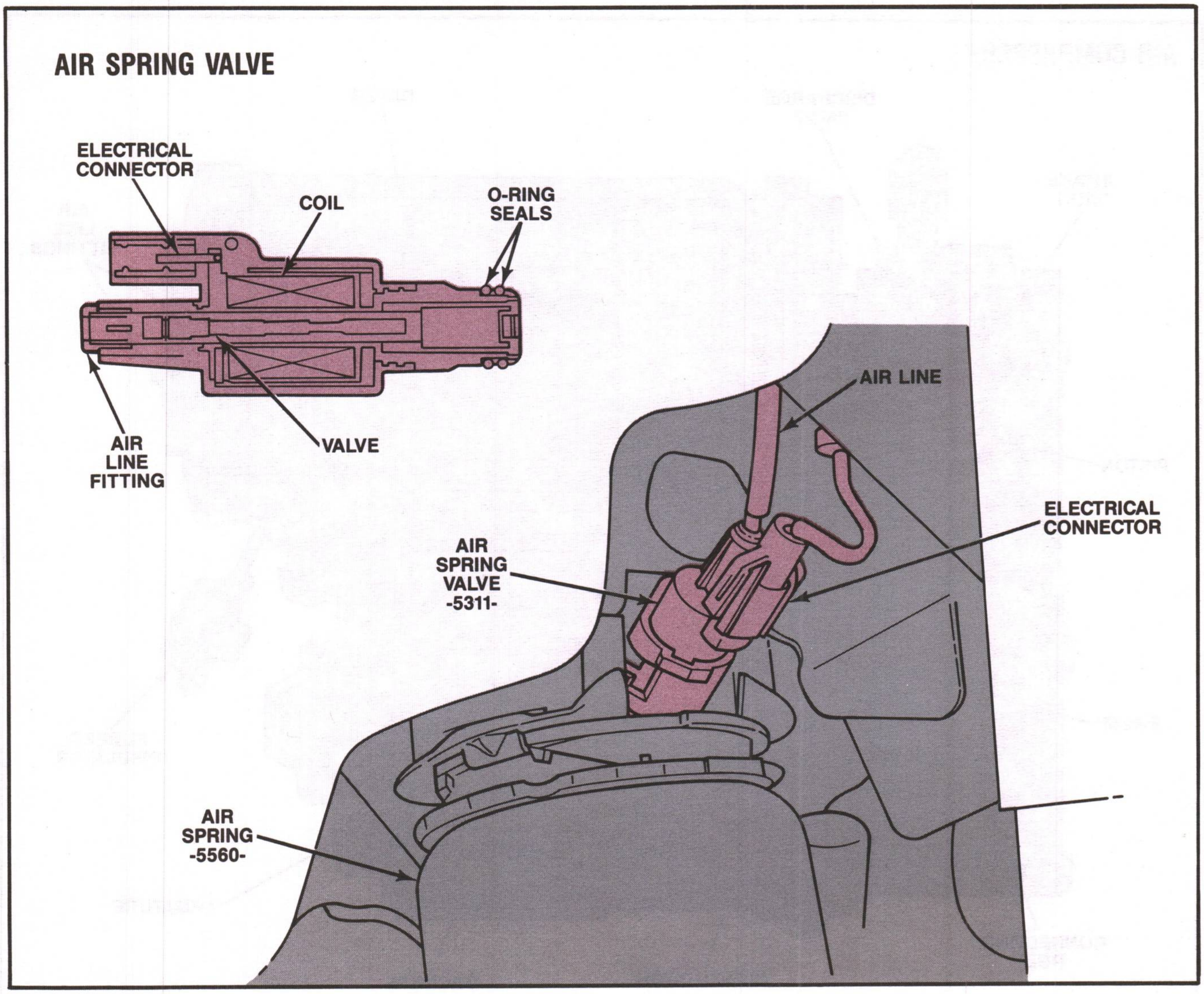
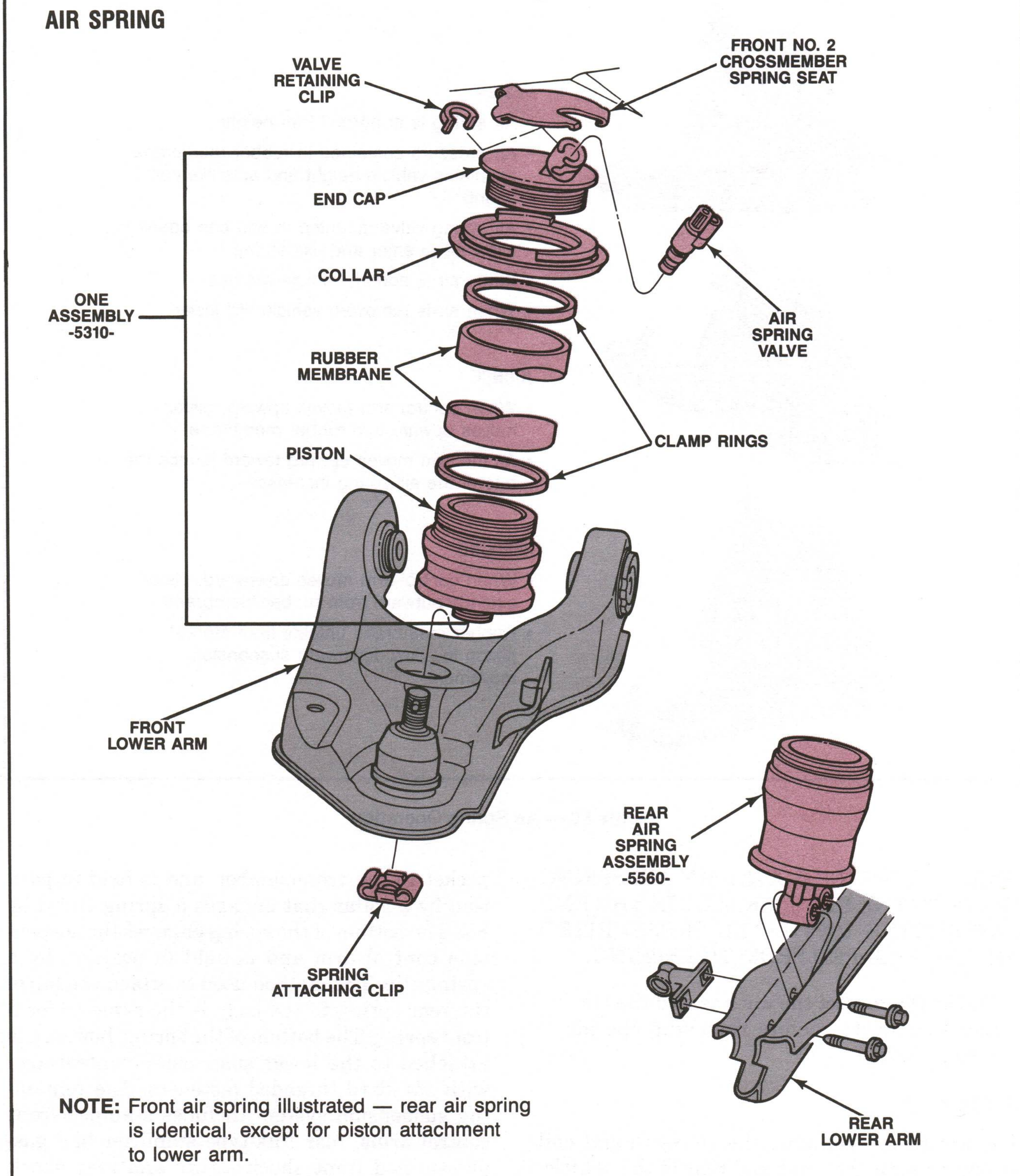

AIR SPRING VALVE
ELECTRICAL CONNECTOR
COIL
O-RING SEALS
AIR LINE FITTING
VALVE
AIR LINE
ELECTRICAL CONNECTOR
AIR SPRING VALVE -5311-
AIR SPRING -5560-

Figure 84 — Air Spring Valve

Air Spring Valve

Air enters and exits the air spring through a solenoid-operated valve mounted on the spring end cap (Fig. 84). The valve is retained in the end cap by a two-stage pressure relief fitting. Air leakage between the valve and end cap fitting is prevented by a double seal that is formed by the spaced O-rings, located on the inlet end of the valve. As a further means of eliminating the possibility of air leakage, the plastic valve body is molded around the internal components to form a single, airtight assembly.

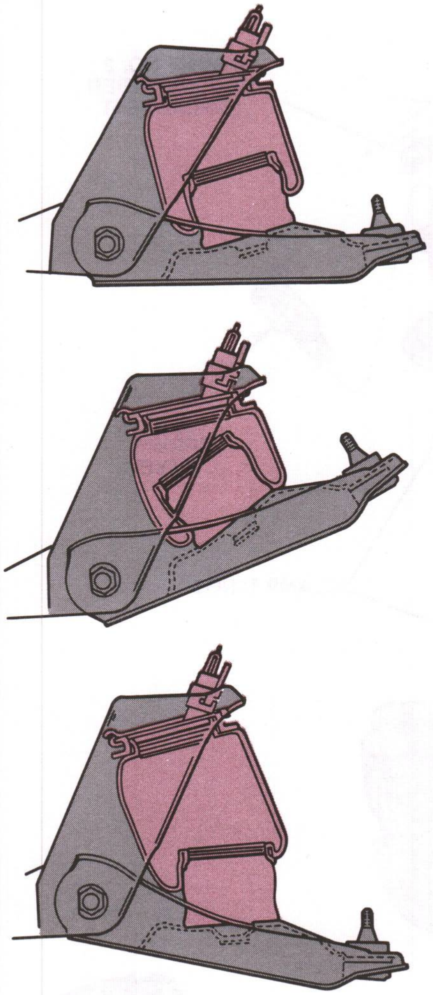
When the valve is installed in the air spring end cap, it is locked in position with a retaining clip. As mentioned, the end cap fitting is of a two-stage design to provide a pressure relief stage and removal stage. This two-step process is a safety feature that allows the release of pressurized air from the spring before the valve is removed. The safety provided by the two-stage fitting is similar to that provided by a radiator pressure cap.


AIR SPRING
VALVE RETAINING CLIP
FRONT NO. 2 CROSSMEMBER SPRING SEAT
END CAP
COLLAR
ONE ASSEMBLY -5310-
AIR SPRING VALVE
RUBBER MEMBRANE
CLAMP RINGS
PISTON
FRONT LOWER ARM
REAR AIR SPRING ASSEMBLY -5560-
SPRING ATTACHING CLIP
REAR LOWER ARM

NOTE: Front air spring illustrated — rear air spring is identical, except for piston attachment to lower arm.

Figure 85 — Air Spring Attachment

AIR SPRING



DESIGN

- Air spring is at normal trim height
- Air pressure contained in rubber membrane maintains vehicle height and acts like coil spring
- Air spring valve mounted in end cap opens to allow air to enter and exit spring
- When air is added, vehicle will rise
- When air is removed, vehicle will lower

JOUNCE

- When control arm moves upward, piston moves upward into rubber membrane
- As the arm moves upward toward jounce the rate of the air spring increases

REBOUND

- When control arm moves downward, piston extends outward from rubber membrane
- Rubber membrane unfolds from around piston to allow downward suspension movement

Figure 86 — Air Spring Operation

WARNING: NEVER ROTATE AN AIR SPRING VALVE TO THE RELEASE SLOT IN THE END CAP FITTING UNTIL ALL PRESSURIZED AIR HAS ESCAPED FROM THE SPRING.

> **NOTE:** Disconnect the air line and the electrical connector before removing the air spring valve.

Air Spring

The air spring replaces the conventional coil spring on both the front and rear of the vehicle. The top of the front spring is attached to a spring pocket in the crossmember, and is held in position by a collar that engages a spring clip (Fig. 85). The bottom of the spring engages the suspension control arm and is held in position by a spring clip. The method used to attach the top of the rear spring to the body is the same as for a front spring. The bottom of the spring, however, is attached to the lower suspension control arm with standard threaded fasteners. The remaining suspension system includes stamped front control arms, rear link-type stabilizer bar, gas-pressurized front shock struts and rear shock absorbers.

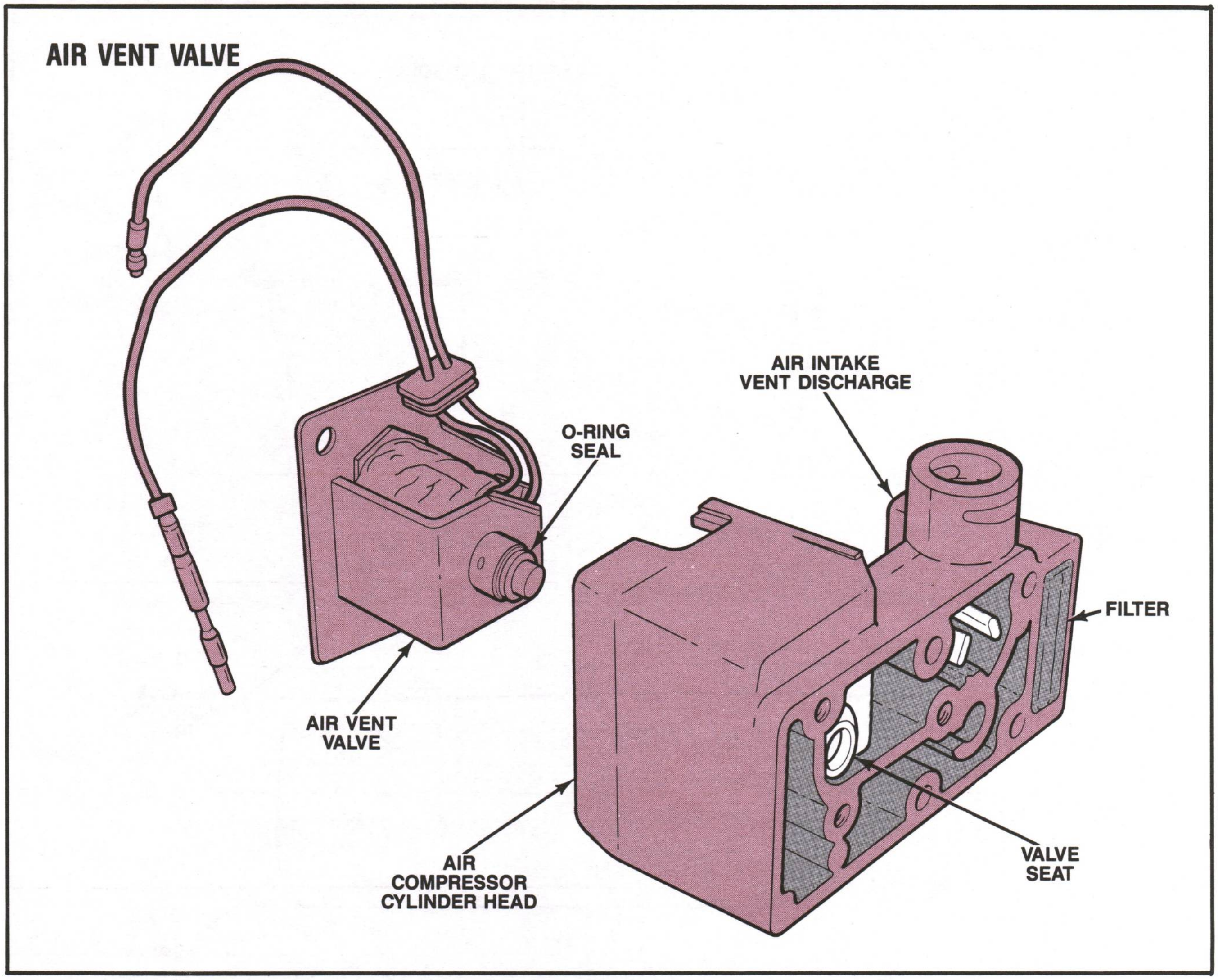


Figure 87 — Air Vent Valve

With the air suspension system, the vehicle weight is actually riding on a cushion of air contained in the rubber membrane. The air pressure within the membrane is high enough and has enough surface area, to support the vehicle. Spring actions such as jounce and rebound are handled by the flexibility of the membrane and the compressibility of the air (Fig. 86).

> **NOTE:** Jounce is the suspension condition that which causes spring compression. Rebound is the expansion of a suspension spring that results from jounce.

If the vehicle load changes, the body height will also change. So that a constant vehicle trim is maintained, the air suspension load-leveling system will add or remove air from the spring. When air is added to the spring, the body will rise and when air is removed from the spring the body will lower. All air entering or exiting the spring passes through the air spring valve, which is mounted in the spring end cap.

Air Vent Valve

Once compressed air has entered the air suspension load-leveling system, its only normal means of escape is through the air vent valve (Fig. 87). The valve is located in the air compressor cylinder head and shares a common electrical connector with the motor.

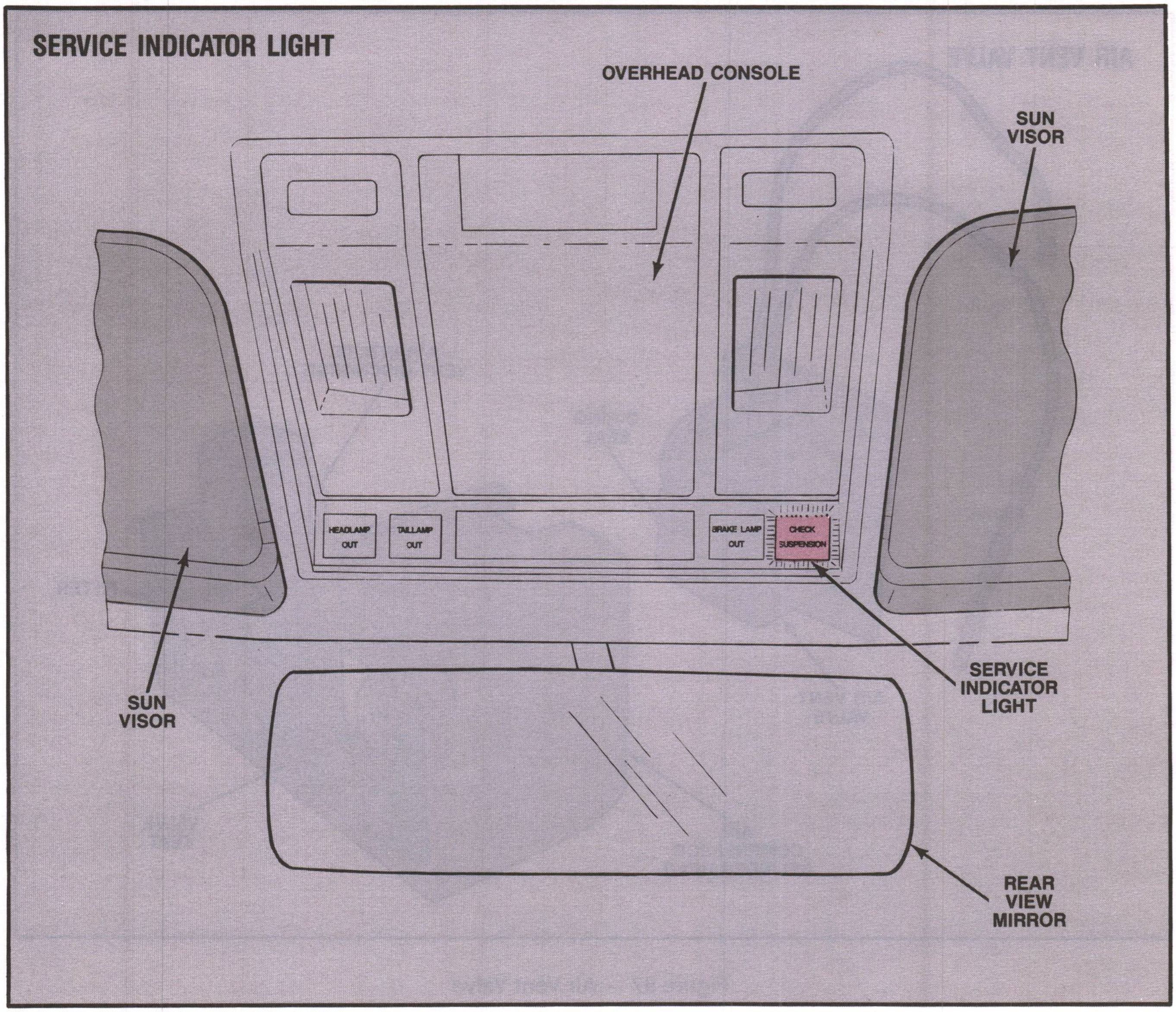

SERVICE INDICATOR LIGHT
OVERHEAD CONSOLE
SUN VISOR
HEADLAMP OUT
TAILLAMP OUT
BRAKE LAMP OUT
CHECK SUSPENSION
SUN VISOR
SERVICE INDICATOR LIGHT
REAR VIEW MIRROR

Figure 88 — Service Indicator Light

The valve is enclosed in the cylinder head casting, which forms an integral valve housing that allows the valve tip to enter the pressurized side of the system. Air leakage past the valve tip is prevented by an O-ring seal.

The vent valve is opened when lowering of the vehicle is required by load changes detected by the module. Lowering of the vehicle requires the module to open at least two valves, the vent valve and one or more air spring valves. When the vent valve is opened, it provides an escape route for pressurized air; but the vehicle will not lower unless the necessary air spring valve is opened to allow air to leave the spring. If both valves are open, air will leave the spring and return to the compressor through the regenerative dryer. As the air passes through the dryer, it collects moisture and carries it out of the system through the compressor cylinder head air intake/vent discharge.

NOTE: The air vent valve is serviced only as part of the air compressor assembly.

Service Indicator Light

The air suspension service indicator light (Fig. 88) is located in the overhead console and has three functions:

- **If the module detects a problem in the air suspension system, the module will illuminate the indicator light to alert the driver to a system problem.**
- **During system self-diagnosis, the light will indicate the module's entry into the diagnostic sequence, flash the sequence test number and indicate a subsystem malfunction during test 1 through 3.**
- **During the air spring fill sequence, the light flashes once every two seconds to indicate that the module has entered the air fill sequence.**

If the system is operating properly, the lamp will come on for one second and then go off when the ignition switch is turned from the OFF to the RUN position.

System Operation

The control module is confronted with a variety of load and driving conditions and has to depend on inputs that will describe each individual condition. The description of each condition contains three elements:

- **Changes in load**
- **Driver and passenger actions**
- **Time**

The first two elements are converted to electrical input signals by the system sensors (height sensors, door switches, ignition switch, brake switch). The third element — time — is measured by circuits contained in the control module. Before sending an output signal, the module checks each input signal against a time element.

The following system operation charts describe typical vehicle conditions. Each chart identifies the necessary descriptive inputs, the module's interpretation of these inputs and the necessary output signals.

LOAD HAS BEEN ADDED TO VEHICLE

INPUTS	MODULE: INTERPRETATION OF INPUTS	MODULE: DECIDED ACTION	OUTPUTS
HEIGHT SENSORS	The weight of the load has lowered the body out of trim. The three height sensors will indicate where the load is positioned: • Left front — driver • Right front — passenger • Rear — rear seat passengeer(s) added fuel, trunk	Add air to the necessary air spring(s) until sensor(s) signal vehicle trim. If both the front and rear need to be raised, the control module will service the rear first.	OPERATE AIR COMPRESSOR BY PROVIDING RELAY GROUND
DOOR SWITCHES	Door(s) have been opened and closed, indicating the driver of passenger(s) have entered the vehicle.		
IGNITION SWITCH	The ignition key is in the RUN position, indicating the vehicle will be driven.		OPEN NECESSARY AIR SPRING VALVE(S)
BRAKE SWITCH	During the first 45 seconds of ignition run, the brake pedal can be pressed without affecting system operation. This allows application of the brake during initial driveaway. After 45 seconds, the brake switch signal will cause the module to ignore sensor-up requests as part of brake inhibit.		
			CLOSE AIR SPRING VALVE(S) WHEN TRIM SIGNAL IS RECEIVED FROM HEIGHT SENSOR(S)

LOAD HAS BEEN REMOVED TO VEHICLE

INPUTS	MODULE		OUTPUTS
	INTERPRETATION OF INPUTS	DECIDED ACTION	
HEIGHT SENSORS	Removal of the load from the vehicle allows the body to rise out of trim. The three height sensors will indicate where the load was removed: • Left front — driver • Right front - passenger • Rear — rear seat passenger(s), fuel removed, trunk	Remove air from the necessary spring(s) until sensor(s) signal vehicle trim. If both the front and rear need to be lowered, the control module will service the rear first.	OPEN NECESSARY AIR SPRING VALVE(S) OPEN VENT VALVE
DOOR SWITCHES	Door(s) have been opened and closed, indicating the driver or passenger(s) have left the vehicle.		
IGNITION SWITCH	The ignition key is in the OFF position, indicating the vehicle has been parked.		CLOSE ALL VALVES WHEN TRIM SIGNAL IS RECEIVED FROM HEIGHT SENSOR(S)

BRAKE INHIBIT

The brake inhibit prevents unnecessary front height adjustments during braking.

INPUTS	MODULE		OUTPUTS
	INTERPRETATION OF INPUTS	DECIDED ACTION	
LEFT AND RIGHT FRONT HEIGHT SENSORS	Norman lowering of the front of the vehicle during braking has caused both front sensors to signal a below-trim condition.	Because the ignition key has been in the RUN position for more than 45 seconds, the module will ignore the height sensor signals while the brakes are applied.	NONE
BRAKE SWITCH	Brakes are applied.		
IGNITION SWITCH	The ignition key is in the RUN position.		

SNOWBANK LOGIC

Snowbank logic prevents over-venting of the air springs when the driver unknowingly parks against an obstacle that raises the body out of trim.

INPUTS

- RIGHT FRONT HEIGHT SENSOR
- LEFT FRONT HEIGHT SENSOR
- REAR HEIGHT SENSOR
- IGNITION SWITCH

MODULE

INTERPRETATION OF INPUTS	DECIDED ACTION
Under this condition, any one of the three sensors may signal an above-trim condition. The ignition key is in the OFF position, indicating the vehicle has been parked.	The vent time is limited to three seconds for the front, and 10 seconds for the rear (provided the ignition switch is turned to the OFF position). Limiting the vent time under this condition prevents over-vent if the vehicle is parked against a snowbank or other obstacle that would hold the vehicle up in an out-of-trim condition.

OUTPUTS

LIMITED OPERATION OF VENT AND AIR SPRING VALVES

45-SECOND AVERAGING

This prevents unnecessary height adjustments when the vehicle is driven into a banked turn that causes body roll, or when the vehicle is driven on an uneven road surface.

INPUTS

- RIGHT FRONT HEIGHT SENSOR
- LEFT FRONT HEIGHT SENSOR
- REAR HEIGHT SENSOR

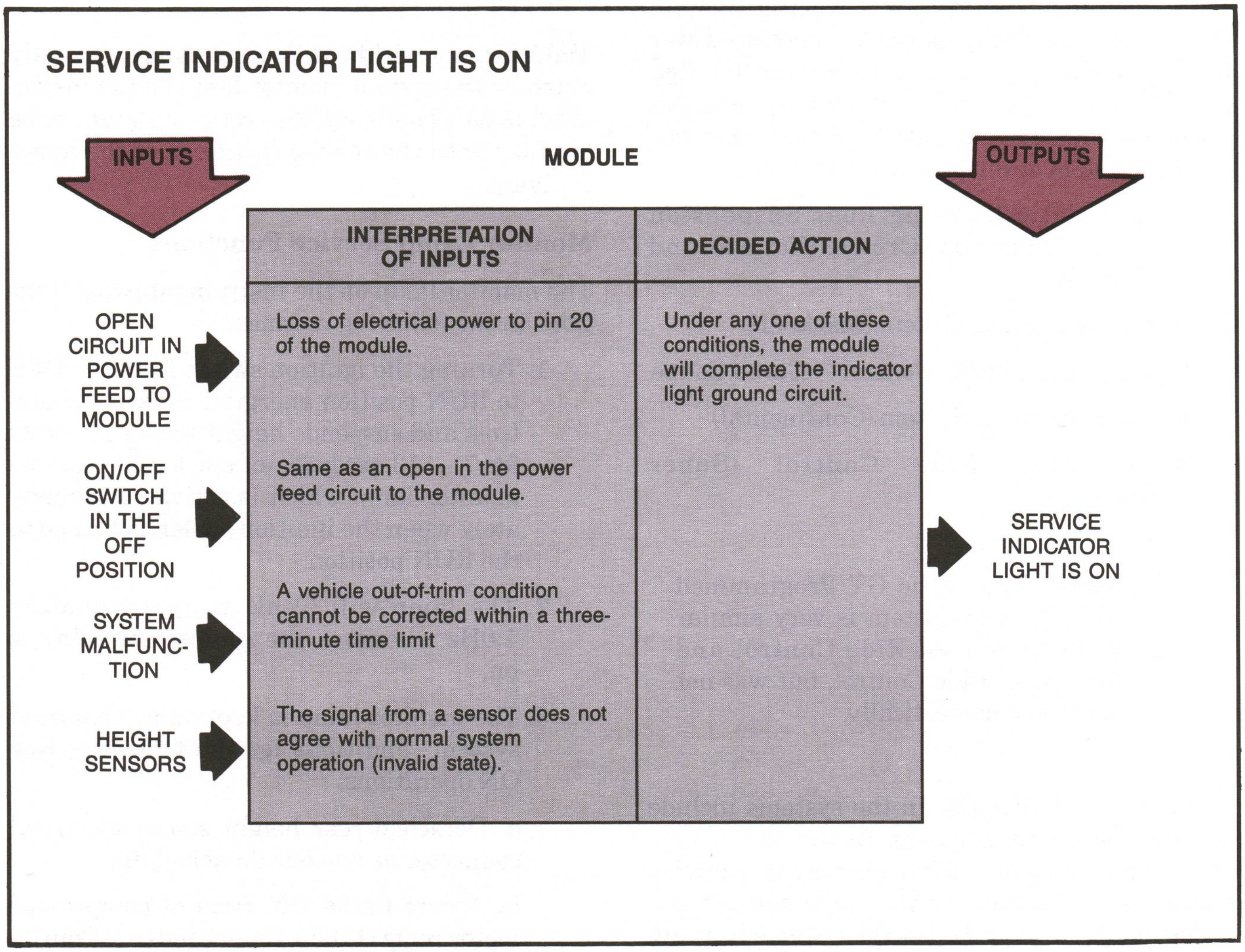
MODULE

INTERPRETATION OF INPUTS	DECIDED ACTION
Under these vehicle conditions, all three sensors may signal an out-of-trim condition.	To prevent unnecessary height corrections, the module will average over time height sensor inputs.

OUTPUTS

NONE

SERVICE INDICATOR LIGHT IS ON



	MODULE		
INPUTS	INTERPRETATION OF INPUTS	DECIDED ACTION	OUTPUTS
OPEN CIRCUIT IN POWER FEED TO MODULE	Loss of electrical power to pin 20 of the module.	Under any one of these conditions, the module will complete the indicator light ground circuit.	SERVICE INDICATOR LIGHT IS ON
ON/OFF SWITCH IN THE OFF POSITION	Same as an open in the power feed circuit to the module.		
SYSTEM MALFUNCTION	A vehicle out-of-trim condition cannot be corrected within a three-minute time limit		
HEIGHT SENSORS	The signal from a sensor does not agree with normal system operation (invalid state).		

System Descriptions Conclusion

This concludes the section covering System Descriptions. As the systems have developed over the years, there has been a continual building and improvement on each successive system. The actual chronology of domestic car electronic suspension system development is as follows:

1. Automatic Leveling Rear Suspension (Grand Marquis, Crown Victoria and Town Car)
2. Air Suspension System (Mark VII)
3. Programmed Ride Control — Turbo Coupe
4. Air Suspension System (Continental)
5. Automatic Ride Control (Super Coupe/XR7)

NOTE: The Probe GT Programmed Ride Control System is very similar to Programmed Ride Control and Automatic Ride Control, but was not developed domestically.

The obvious similarities in the systems include several similar components. In the air suspension systems this would include air compressors, tubing, relays, control valves, input sensors and other items. In the ride control systems it would include input sensors, actuating devices, struts and shocks.

Although the systems may contain many similar components and have some like operations there are major differences. This will become obvious in the next section which details the diagnostics for each of the electronic suspension systems.

SUSPENSION SYSTEM DIAGNOSIS

This section discusses diagnosis and testing on each of the electronic suspension systems. In most cases the descriptions will only discuss the self-test or quick-test procedures and points to be familiar with. Full and complete diagnostic tests, specific procedures and pinpoint tests are included in the Shop Manual for the vehicle being serviced.

Automatic Leveling Rear Suspension System Diagnosis

Malfunctions within this systems are typically noted by the system monitor lamp on the instrument panel. Therefore, it is very important to be familiar with the service functions of the monitor lamp.

Monitor Lamp Service Functions

The monitor lamp on the instrument panel functions in the following manner:

1. Turning the ignition switch from the OFF to RUN position energizes all system controls and suspends height sensor requests for 7 — 13 seconds, except for the service monitor lamp which is activated immediately when the ignition switch is turned to the RUN position.
2. The lamp will blink at approximately 1.0Hz whenever the compressor relay is on.
3. The monitor lamp is kept on at abnormal system conditions for the following Key ON operations:

   a. Detached rear height sensor electrical connector or any one detached line.

   b. Accumulated ON time of compressor motor relay (110 to 130 seconds). c. Continuous ON of vent solenoid (55 — 65 seconds).

   c. Continuous ON of vent solenoid (55 - 65 seconds).

   NOTE: If the rear height lowers to or below trim position, the vent operation is reset and the monitor lamp turns off, for both Key ON and Key OFF operations.

4. When abnormal program run is detected, the control module suspends all controls and the service monitor lamp remains on.
5. All system functions of the control module, except compressor relay on, are energized for 29 — 31 minutes after ignition switch is turned to the OFF position.

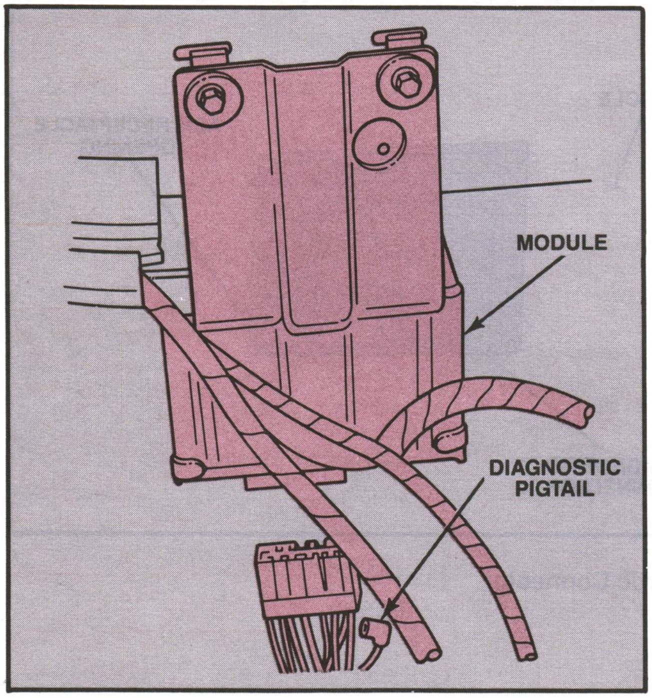


Figure 89 — Diagnostic Pigtail

System Testing

There are three quick tests that check the load leveling rear suspension. The first one, test A, is to check the vehicle load at its curb height. Test B is used to check the monitor lamp and Test C is a test which initializes the system and causes the system to run through its electronically controlled operations.

To perform parts B and C of the quick test, a test lamp is required. This lamp can be fashioned on site using instructions found in Section 14-37 of the Town Car/Crown Victoria/Grand Marquis Shop Manual.

To perform the testing, use lamp must be attached to the diagnostic pigtail located in the luggage compartment on the right quarter panel near the control module(Fig. 89).

Specific conditions that a vehicle could exhibit include:

- **System Inoperative**
- **Vehicle low or high: vehicle rises and lowers OK when load is added or removed, but normal trim height seems high or low.**
- **Vehicle rises OK, but gradually leaks down.**
- **Compressor cycles on and off intermittently while driving.**
- **Compressor runs continuously for two minutes with ignition switch in RUN. Vehicle may not rise.**
- **Compressor turns off after two minutes of accumulated operating time. Vehicle may not rise.**
- **Vehicle high or will not lower with ignition switch ON or OFF.**
- **Vehicle low or compressor does not run with ignition switch ON and a load applied.**
- **Excessive bottoming in rear with load.**

If a vehicle should exhibit any of these conditions refer to Section 14-37 of the Town Car/Crown Victoria/Grand Marquis Shop Manual for diagnostic information.

Turbo Coupe Programmed Ride Control Diagnostics

The Turbo Coupe Programmed Ride Control System has built in self-test capabilities similar to other electronic control systems. This test procedure will identify specific areas of the system which are not functioning correctly, and output a code through the ride control indicator lamp. These codes can be used to locate the exact cause of a malfunction in the Shop Manual Diagnostic Charts.

During normal operation, the control module continuously monitors the entire system. In the event of a malfunction, the firm ride lamp on the tachometer face will flash. By moving the switch to the opposite position and back, erroneous codes can be cleared from the memory. If the lamp continues to flash, the system self-test should be run to determine the area of the malfunction.

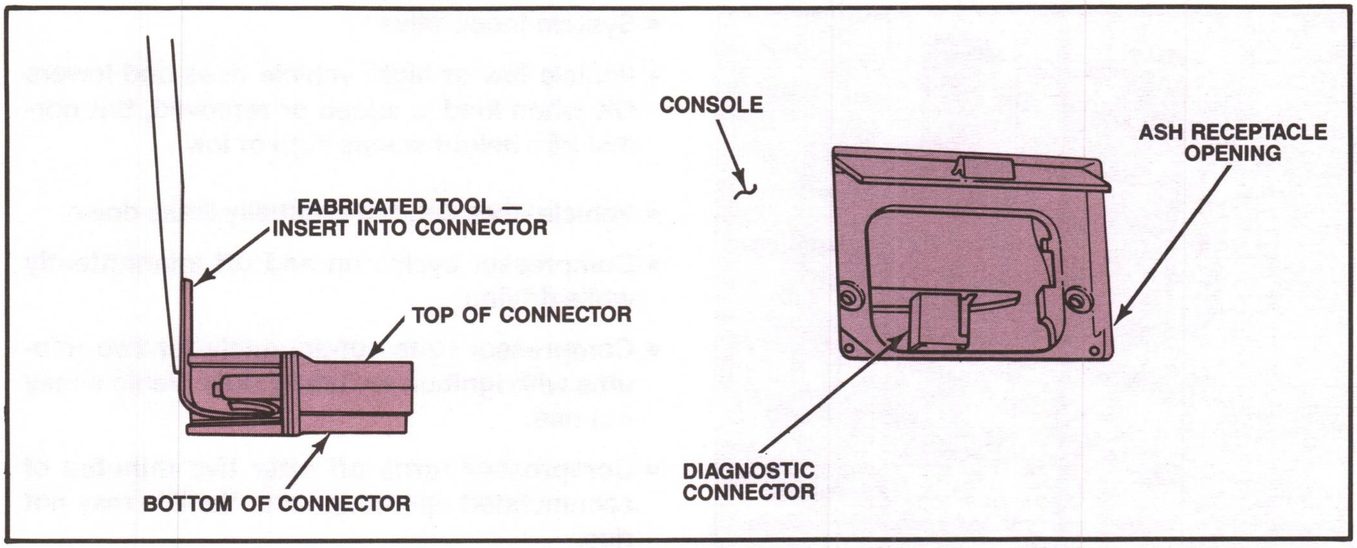

CONSOLE
ASH RECEPTACLE OPENING
FABRICATED TOOL — INSERT INTO CONNECTOR
TOP OF CONNECTOR
BOTTOM OF CONNECTOR
DIAGNOSTIC CONNECTOR

Figure 90 — Diagnostic Connector

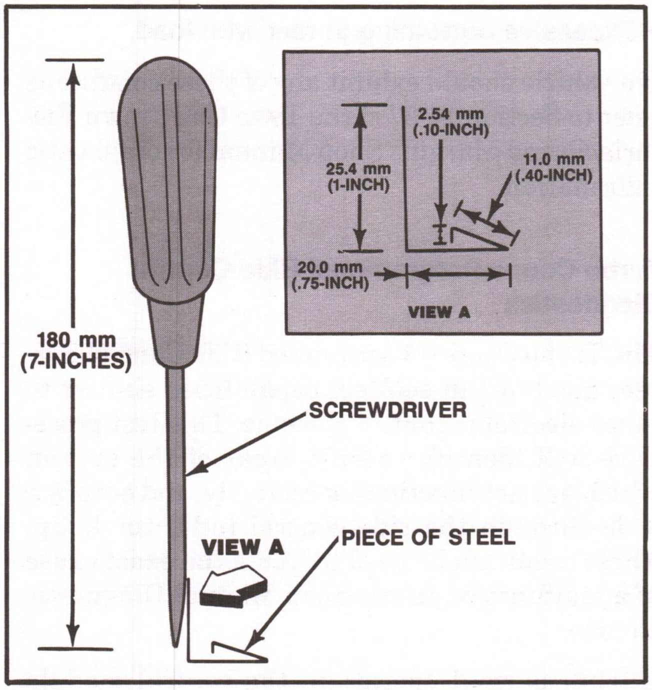

2.54 mm (.10-INCH)
25.4 mm (1-INCH)
11.0 mm (.40-INCH)
20.0 mm (.75-INCH)
VIEW A
180 mm (7-INCHES)
SCREWDRIVER
VIEW A
PIECE OF STEEL

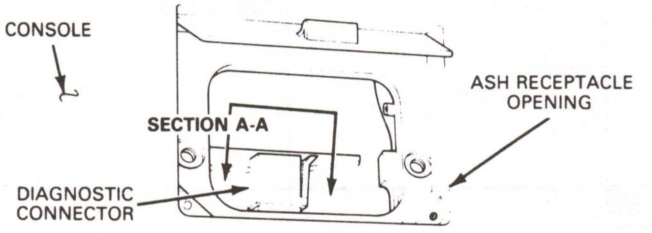
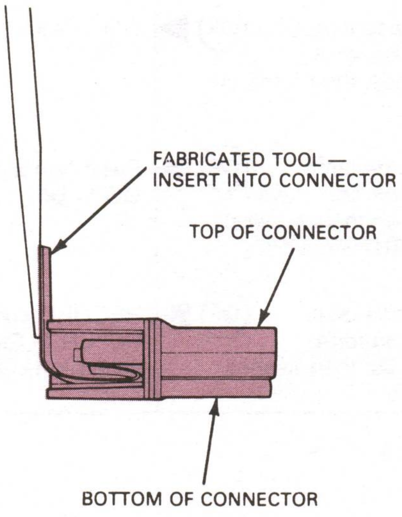
Figure 91 — Fabricated Jumper Tool

To initiate a self-test, a jumper must be placed in the diagnostic connector which is located below the ash tray (Fig. 90). Fabricate a jumper tool as shown (Fig. 91), and Solder it to a screwdriver that is at least 7 inches long. The self-test procedure can now be performed.

Self-Test

The self test procedures outlined in steps A1 through A7 are intended to check the electrical circuitry and determine the area responsible for a system malfunction. Test sequences B through D are located in section 14-39 of the Thunderbird/Cougar Shop Manual and must be used to determine the exact cause of the malfunction and the action required to correct it.

QUICK TEST

TEST STEP	RESULT	ACTION TO TAKE
A1 ENTER DIAGNOSTICS • Turn ignition switch to the OFF position. • Ensure headlamps and parking lamps are in the OFF position during the entire test. • Set shock select switch to the AUTO position. • Remove ash receptacle from console and insert fabricated tool in diagnostic connector as shown.  CONSOLE ASH RECEPTACLE OPENING SECTION A-A DIAGNOSTIC CONNECTOR • Do NOT move shock select switch during test. • Start engine and perform the following steps while engine is running. 1. Remove fabricated tool from diagnostic connector within 20 seconds of starting the engine. 2. Count the blinks of the firm ride lamp in the tachometer. NOTE: The lamp will blink the same code four times, once every 9 seconds.  FABRICATED TOOL — INSERT INTO CONNECTOR TOP OF CONNECTOR BOTTOM OF CONNECTOR	Firm ride lamp blinks one of the following codes four times.	
	6 ▶	No problem yet. GO to **A2**.
	1 ▶	Fault in LH rear actuator circuit. GO to **B1**.
	2 ▶	Fault in RH rear actuator circuit. GO to **B8**.
	3 ▶	Fault in RH front actuator circuit. GO to **B8**.
	4 ▶	Fault in LH front actuator circuit. GO to **B8**.
	5 ▶	Short in Soft relay GO to **B21**.
	7 ▶	REPLACE Programmed Ride Control (PRC) module.
	1 then 3 ▶	Shoft in hard relay control. GO to **B25**.
	1 then 4 ▶	Fault in relay control circuit. GO to **B25**.
	Firm ride lamp does not turn on ▶	GO to **C1**.
	Firm ride lamp comes on and stays on even though switch is in AUTO position ▶	Fault in lamp control. GO to **C17**.

QUICK TEST — Continued

TEST STEP	RESULT ▶	ACTION TO TAKE
A2 CHECK STEERING SENSOR		
NOTE: Steps A2 and A3 may be repeated as many times and in any order desired to ensure proper test results. However, once the engine is turned off or the shock select switch is moved, you must proceed to step A4 or start over at step A1. • Wait until lamp has stopped blinking. • With the vehicle at rest and engine running, test the steering sensor by turning the steering wheel from lock in one direction to lock in the other direction (3 full turns) or until firm ride lamp turns on. **NOTE: The lamp will usually turn on before the wheel has completed the lock turn. This is normal.**	Firm ride lamp turns on for 5 seconds, then turns off OK ▶	GO to **A3**.
	Firm ride lamp does not turn on ~~OK~~ ▶	Fault in steering sensor circuit. GO to **D13**.
A3 CHECK SPEED SENSOR		
• Wait until lamp has turned off from Step A2. • Drive the vehicle at any desired speed above 15 mph (24 Km/h).	Firm ride lamp turns on and stays on until vehicle speed drops below 15 mph (24 Km/h) OK ▶	GO to **A4**.
	Firm ride lamp does not turn on ~~OK~~ ▶	Fault in speed sensor circuit. GO to **D19**.
A4 PREPARE FOR REMAINING TESTS		
• Stop vehicle and turn engine off. • Move shock select switch to AUTO if it is not already there. • Move the ignition switch to the RUN position, leaving the engine off. • Wait until the firm ride lamp has turned off (usually after 4 seconds).	Firm ride lamp turns on for 4 seconds, then turns off OK ▶	GO to **A5**.
	Firm ride lamp turns on and stays on even though switch is in AUTO position ~~OK~~ ▶	False firm signal. GO to **D6**.
	Firm ride lamp turns on for 4 seconds, then flashes a code ~~OK~~ ▶	RECORD code and REFER to Step A1 for action to take.

QUICK TEST — Continued

TEST STEP	RESULT ▶	ACTION TO TAKE
A5 CHECK SHOCK SELECT SWITCH		
NOTE: Steps A5 through A6 may be performed in any order and as many times as desired to ensure satisfactory results. • Move the shock select switch to AUTO if it is not already there. • After the firm ride lamp has turned off, move the shock select switch to the FIRM position. • After the firm ride lamp has turned on, move the shock select switch back to the AUTO position.	Firm ride lamp turns on in FIRM, off in AUTO OK ▶	GO to **A6**.
	Firm ride lamp does not turn on ~~OK~~ ▶	Fault in shock select switch circuit. GO to **D23**.
	Firm ride lamp flashes a code ~~OK~~ ▶	RECORD code and REFER to Step A1 for action to take.
A6 CHECK BRAKE SENSOR		
• Move the shock select switch to AUTO if it is not already there. • After the firm ride lamp has turned off, depress the brake pedal until the firm ride lamp turns on. • After the firm ride lamp has turned on, release the brake pedal.	Firm ride lamp turns on OK ▶	GO to **A7**.
	Firm ride lamp does not turn on ~~OK~~ ▶	Fault in brake sensor circuit. GO to **D27**.
	Firm ride lamp flashes a code ~~OK~~ ▶	RECORD code and REFER to Stop A1 for action to take.
A7 CHECK ACCELERATION SIGNAL		
• Move the shock select switch to AUTO if it is not already there. • After the firm ride lamp has turned off, depress the accelerator pedal to the floor. The firm ride lamp should turn on. • After the firm ride lamp has turned on, release the accelerator pedal.	Firm ride lamp turns on when pedal is pressed to the floor, off 4 seconds after the pedal is released ~~OK~~ ▶	If the complete test has been completed (Steps A1 through A7), then the vehicle has passed diagnostics.
	Firm ride lamp does not turn on ~~OK~~ ▶	Fault in acceleration signal circuit. GO to **D31**.
	Firm ride lamp flashes a code ~~OK~~ ▶	RECORD code and REFER to Step A1 for action to take.

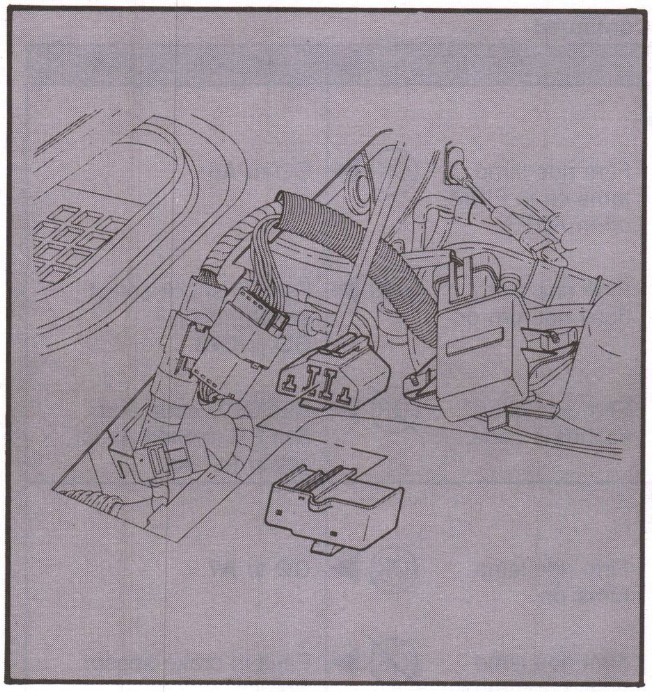


Figure 92 — Diagnostic Connector

Automatic Ride Control

The Automatic Ride Control System used on the Thunderbird Super Coupe and Cougar XR7 feature computer assisted diagnostics using the STAR or Super STAR II hand held diagnostic tester, Rotunda 007-00017 or 007-00028.

Diagnostic on the Automatic Ride Control System also include the EVO Steering System (covered in this manual). The major components of the Automatic Ride Control and EVO systems, including the self-test connector (located near right shock tower in engine compartment) are as shown (Fig. 92).

It should be noted that whenever the system is in the firm ride mode, regardless of switch position, the firm ride lamp will come on (Fig. 93). In the event of a malfunction, the firm ride lamp will flash on and off.

The flashing actually indicates codes. If there is a code stored, the code will flash on the lamp when the key is turned to the ON position.

The following chart (Fig. 94) shows the quick test procedure using the STAR Tester or Super STAR II Tester. Note the STAR codes and firm ride lamp blinks.

Probe GT Programmed Ride Control Diagnostics

There are three different test procedures to follow for the Programmed Ride Control Quick Test.

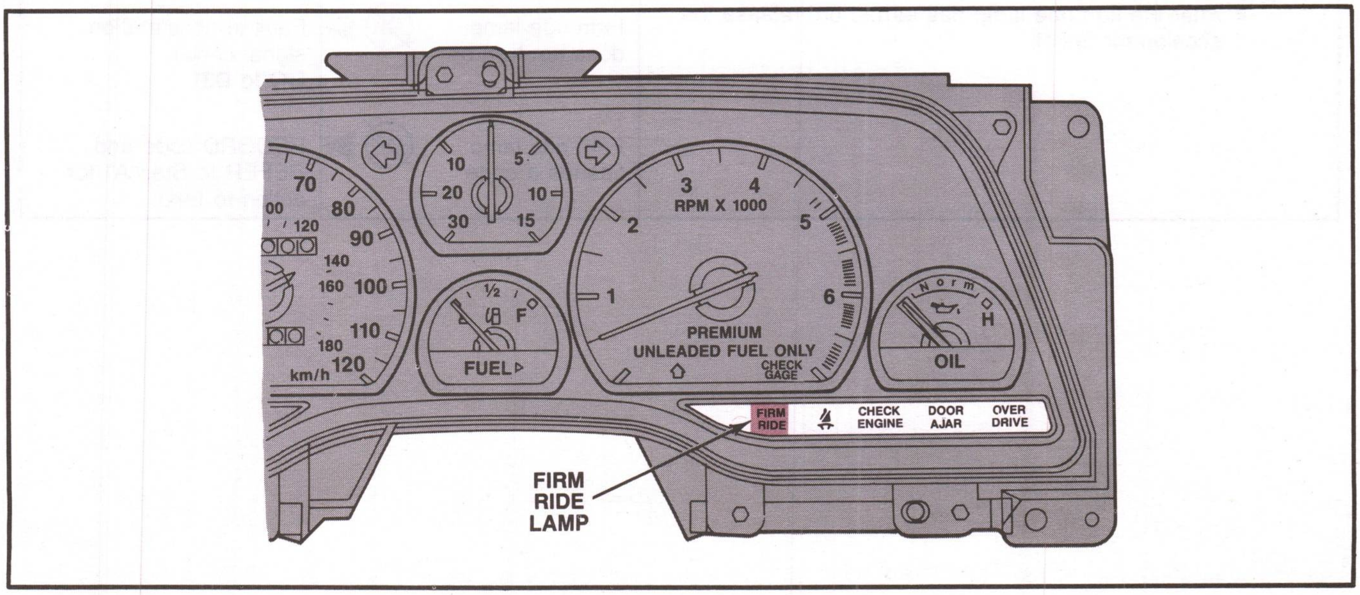


Figure 93 — Firm Ride Lamp

QUICK TEST

TEST STEP

A1 ENTER DIAGNOSTICS

- Turn ignition switch to the OFF position
- Ensure headlamps and parking lamps are in the OFF position during the entire test
- * Set shock select switch to the AUTO position.
- Take Rotunda Super Star II (Model 007-00019, 007-00028) or Star (Model 007-00017) Tester or equivalent and place in the "Hold" up position. Format for the Super Star II can be in slow or fast format for status codes.
- Connect Super Star II or Star tester to ST1 connector marked "ARC/EVO," located under hood by the passenger side shock tower.
- Turn the Star Tester on, and depress the Star test button to the "TEST" down position.
  NOTE: If using a Super Star II tester, make sure the mode switch is in the EEC-IV, MCU mode not the MECS mode. If in MECS mode you will get invalid error codes.
- Do NOT move shock select switch during test
- Start engine and perform the following steps while engine is running.
  1. The following procedure must be initiated within 20 seconds after starting the engine.
  2. Release Star tester in the "TEST" mode to the "HOLD" mode and back to the "TEST" mode within 5 seconds.
  3. The ARC/EVO module will run through self-test procedure and record error codes to the Star tester and also pulse out error codes to the firm ride lamp.
     NOTE: The lamp will blink the same code two times.

* NOTE: Switch must be set in AUTO position; otherwise, a code 21 will be displayed.

RESULT		ACTION TO TAKE
Star codes	Firm ride lamp blinks the following codes two times.	
11	1 THEN 1	No problem yet
10	1	Fault in LH rear actuator circuit
20	2	Fault in RH rear actuator circuit
30	3	Fault in RH front actuator circuit
40	4	Fault in LH front actuator circuit
50	5	Short in soft relay
60 Circuit	6	EVO steering open
70	7	REPLACE automatic ride control module
12	1 THEN 2	Soft relay short to ground or open circuit
13	1 THEN 3	Hard relay short to ground or open circuit
14	1 THEN 4	Fault in relay control circuit
15	ON ALWAYS	Firm ride lamp short to ground or open circuit
16	1 THEN 6	EVO steering circuit short
22	2 THEN 2	Soft relay short to battery
23	2 THEN 3	Hard relay short to battery
25		Firm ride lamp short to battery ground
26	2 THEN 6	EVO steering valve bad
00		Refer to Automatic Ride Control Diagnostics in Shop Manual Section 14-39

Figure 94—Automatic Ride Control/EVO Steering System Quick Test

SYMPTOM	POSSIBLE CAUSE	ACTION TO TAKE
Excessive body roll	Steering angle sensor, control unit, wiring harness, actuators	Go to PRC Quick Test
Excessive dive or squat under hard braking or acceleration	Vehicle speed sensor, control unit, actuators, wiring harness	Go to PRC Quick Test
Suspension setting does not correspond to PRC switch position	Actuators, control unit, wiring harness, PRC switch.	Go to PRC Quick Test
Suspension setting does not change when switch is changed	Actuator, wiring harness, PRC switch, control unit.	Go to PRC Quick Test

Figure 95 — Symptom Chart

- **Test A — Checks the steering angle sensor operation within the PRC system. The test is performed by turning the steering wheel right and left and following the procedure outlined for the Key ON Engine OFF Quick Test.**
- **Test B — Checks the ride control switch operation within the PRC system. The test is performed by changing the PRC switch from NORMAL to SPORT and from NORMAL to SOFT following the procedure outlined for the Key ON Engine OFF Quick Test and Continuous Quick Test.**
- **Test C — Checks vehicle speed sensor operation within the PRC system. The test is performed by jacking up the front of the vehicle and rotating the front wheels at above 15 km/h (9.3 mph) following the procedures outlined for the Key ON Engine OFF Quick Test.**

The following chart indicates the types of symptoms associated with the PRC Quick Tests (Fig. 95). Refer to the Probe Shop Manual for further PRC Quick Test Information.

Visual Inspection and Vehicle Preparation

Before performing any test, visually inspect the vehicle for any abnormal conditions such as loose wires, improper connections, or damaged hoses. Make any necessary repairs before continuing with the Quick Tests.

Equipment Hookup

An analog volt-ohmmeter (VOM) can be used to read programmed ride control service codes (Fig. 96). Use the following instructions to hook up the VOM. It should be noted that the PRC test connector and VAPS (Variable Assist Power Steering) test connector are the same connector.

1. Turn the ignition key OFF to reset the control unit.
2. Set the VOM on a DC voltage range to read from 0 to 15 volts.
3. Connect the VOM red (+) lead to the blue/white terminal and the black (-) lead to the black terminal.

NOTE: The Programmed Ride Control test codes are separated by a two second pause, unlike the Variable Assist Power steering codes which are repeated in ten second intervals.

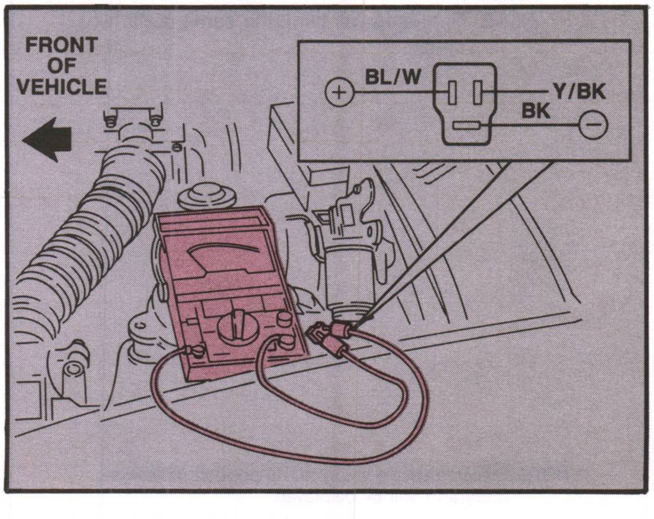


Figure 96 — Equipment Hookup

Key ON Engine OFF Quick Test:

Use the chart (Fig. 97) in conjunction with the information presented in this segment.

Begin with Test Step A (turning the steering wheel right and left) following the instructions in the test step column. While performing Test Step A, ignore the code pulses retrieved when the steering wheel is in the center position. A pass code in the "Action to Take" column indicates that no faults have been detected and therefore you should proceed to the next test step.

1. Turn the ignition key off to reset the control unit before performing each test.
2. Attach the VOM as instructed in Equipment Hookup.
3. Turn the ignition key ON.
4. Place the steering wheel in the straight ahead position.
5. Turn the VOM on.
6. Record all service codes displayed and refer to "Test Step B" in the code output chart. Perform Test Step B.
7. Jack up the front of the vehicle.
8. Rotate the front wheels at above 15 km/h (9.3 mph). The engine can be started to rotate the wheels for this part of the test.

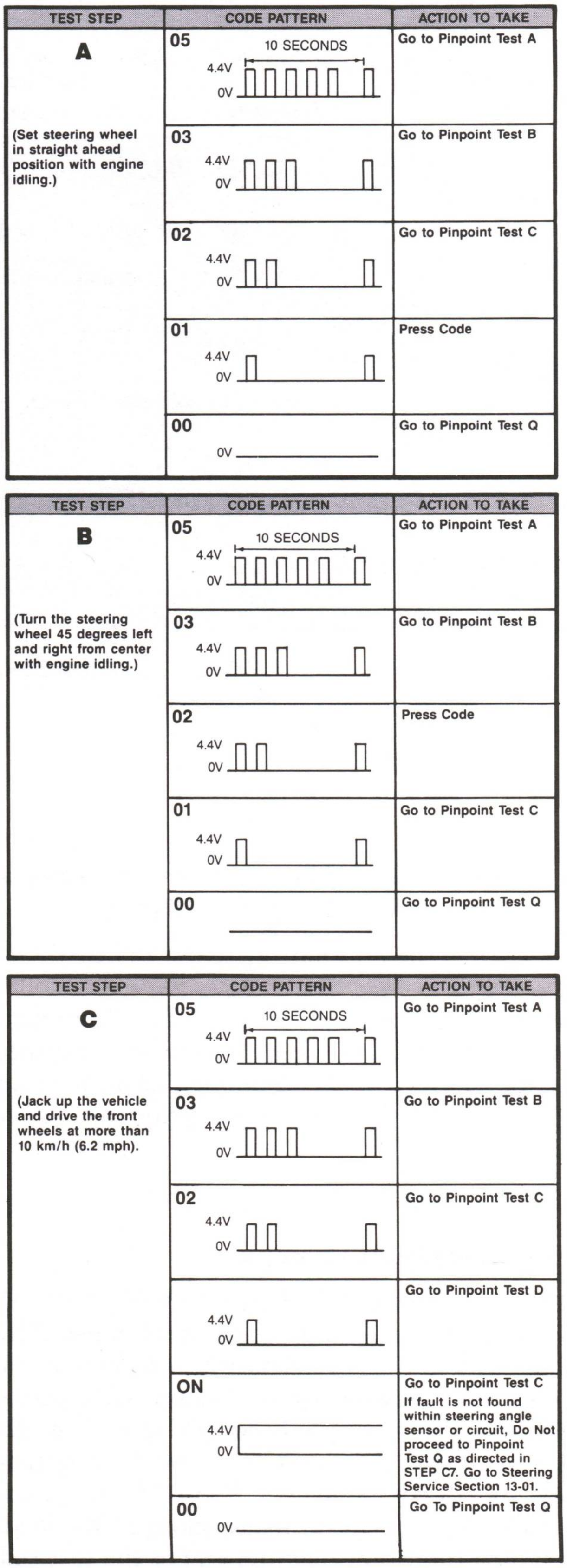
   NOTE: The code output chart shows volt-ohmmeter pulses, notice that the same code pattern can sometimes indicate different faults in different quick test steps.

9. Record all service codes displayed and refer to "Test Step C" in the code output chart.

   If a pass code is indicated in all steps of the Key ON Engine OFF Quick Test, continue on with the Continuous Quick Test.

Continuous Quick Test

The Continuous Quick Test provides an opportunity to try and recreate an intermittent fault. Before conducting the Continuous Quick Test, make sure that a pass code was indicated in all steps of the Key ON Engine OFF Quick Test.



TEST STEP	CODE PATTERN	ACTION TO TAKE
A (Set steering wheel in straight ahead position with engine idling.)	05 10 SECONDS 4.4V 0V	Go to Pinpoint Test A
	03 4.4V 0V	Go to Pinpoint Test B
	02 4.4V 0V	Go to Pinpoint Test C
	01 4.4V 0V	Press Code
	00 0V	Go to Pinpoint Test Q

TEST STEP	CODE PATTERN	ACTION TO TAKE
B (Turn the steering wheel 45 degrees left and right from center with engine idling.)	05 10 SECONDS 4.4V 0V	Go to Pinpoint Test A
	03 4.4V 0V	Go to Pinpoint Test B
	02 4.4V 0V	Press Code
	01 4.4V 0V	Go to Pinpoint Test C
	00	Go to Pinpoint Test Q

TEST STEP	CODE PATTERN	ACTION TO TAKE
C (Jack up the vehicle and drive the front wheels at more than 10 km/h (6.2 mph).	05 10 SECONDS 4.4V 0V	Go to Pinpoint Test A
	03 4.4V 0V	Go to Pinpoint Test B
	02 4.4V 0V	Go to Pinpoint Test C
	4.4V 0V	Go to Pinpoint Test D
	ON 4.4V 0V	Go to Pinpoint Test C If fault is not found within steering angle sensor or circuit, Do Not proceed to Pinpoint Test Q as directed in STEP C7. Go to Steering Service Section 13-01.
	00 0V	Go To Pinpoint Test Q

Figure 97 — Test Procedures

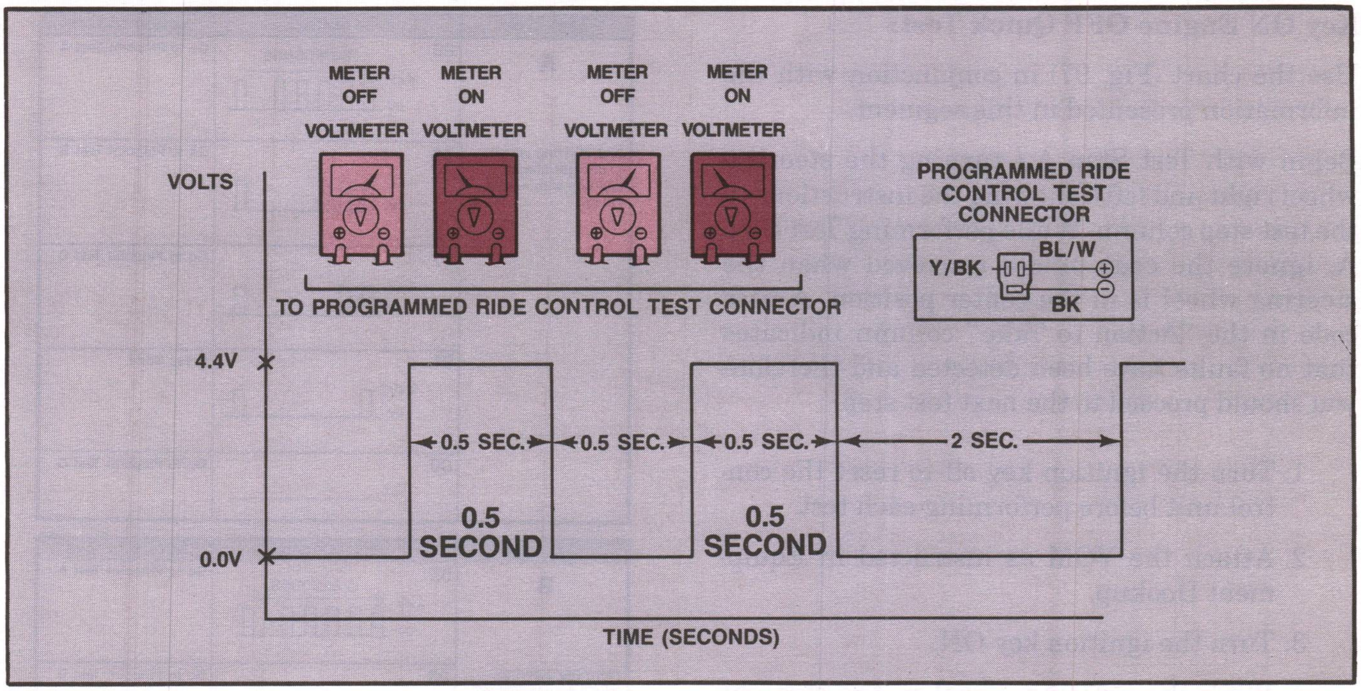

METER OFF
VOLTMETER
METER ON
VOLTMETER
METER OFF
VOLTMETER
METER ON
VOLTMETER
VOLTS
PROGRAMMED RIDE CONTROL TEST CONNECTOR
Y/BK
BL/W
BK
TO PROGRAMMED RIDE CONTROL TEST CONNECTOR
4.4V
0.0V
0.5 SEC.
0.5 SEC.
0.5 SEC.
2 SEC.
0.5 SECOND
0.5 SECOND
TIME (SECONDS)

Figure 98 — Test Step A Code 02 Pattern Example

1. Attach the VOM to the test connector as instructed in Equipment Hookup.
2. Turn the ignition key to the ON position.

At this point the system is in the Continuous Monitor Mode. Tap, wiggle, and move the suspect sensor and/or harness while running all the steps of "Test Step B." Follow the appropriate "Action to Take."

PRC Test Codes Example

All Programmed Ride Control Quick Test code patterns are single digit codes. Each pulse of the code will last approximately 0.5 second and pulses are separated by a 5.0 second time period. Refer to the example code provided (Fig. 98). After a code has been completed, it will be repeated again following a 2 second time period. This 2 second period provides enough time to distinguish the beginning and end of the test code pattern.

Continental Air Suspension System Diagnostics

Diagnostics on the Continental Air Suspension System are quite detailed. The overall system analysis can be divided into three parts.

- **Drive Cycle Diagnostics**
- **Service Bay Diagnostics**
- **Spring Fill Diagnostics**

All three parts require the use of the Rotunda STAR (007-00004) or Super STAR II Tester (007-00041). The Super STAR Tester (007-00019) cannot be used.

If a malfunction should occur in the Continental Air Suspension System while driving, the ride control warning lamp in the message center will light. This indicates that a code is stored and that it can be retrieved using Drive Cycle Diagnostics. tics.

Drive Cycle Diagnostics

This part of diagnostics will display any error codes that have occurred during the last drive cycle (Ignition ON Cycle). This test was designed primarily to test the vehicle speed input and provide a means of detecting intermittent faults which may not be found when running the Service Bay Diagnostic test.

The test is run basically by driving the vehicle until either the "RIDE CONTROL" message is displayed or the technician feels that the vehicle has been driven for an adequate period of time. The vehicle should then be driven directly to the service area and parked with the ignition in the OFF position.

> **NOTE:** The fault codes are now stored for up to one hour of ignition OFF time or until the ignition is turned back to the ON position. Therefore care must be taken not to turn the ignition back ON since this will erase any failure codes which have been stored.

A STAR tester should now be connected followed by depressing the test button. The tester will display either a pass code or one or more fault codes. There are 32 possible fault codes. Any codes will be continuously displayed until either the ignition has been OFF for one hour or the ignition is turned back ON.

Service Bay Diagnostics

This part of the diagnostics is divided into three areas:

- **Auto/Manual Diagnostic Check**
- **Fault Code Display**
- **Pinpoint Tests**

Auto/Manual Diagnostic Check — This test allows the air suspension control module to verify itself and to check the operation of various components. After performing these tests, The STAR Tester will display "12/okay to do manual checks" or 13/Faults detected do manual checks." The manual input checks should be performed at this time.

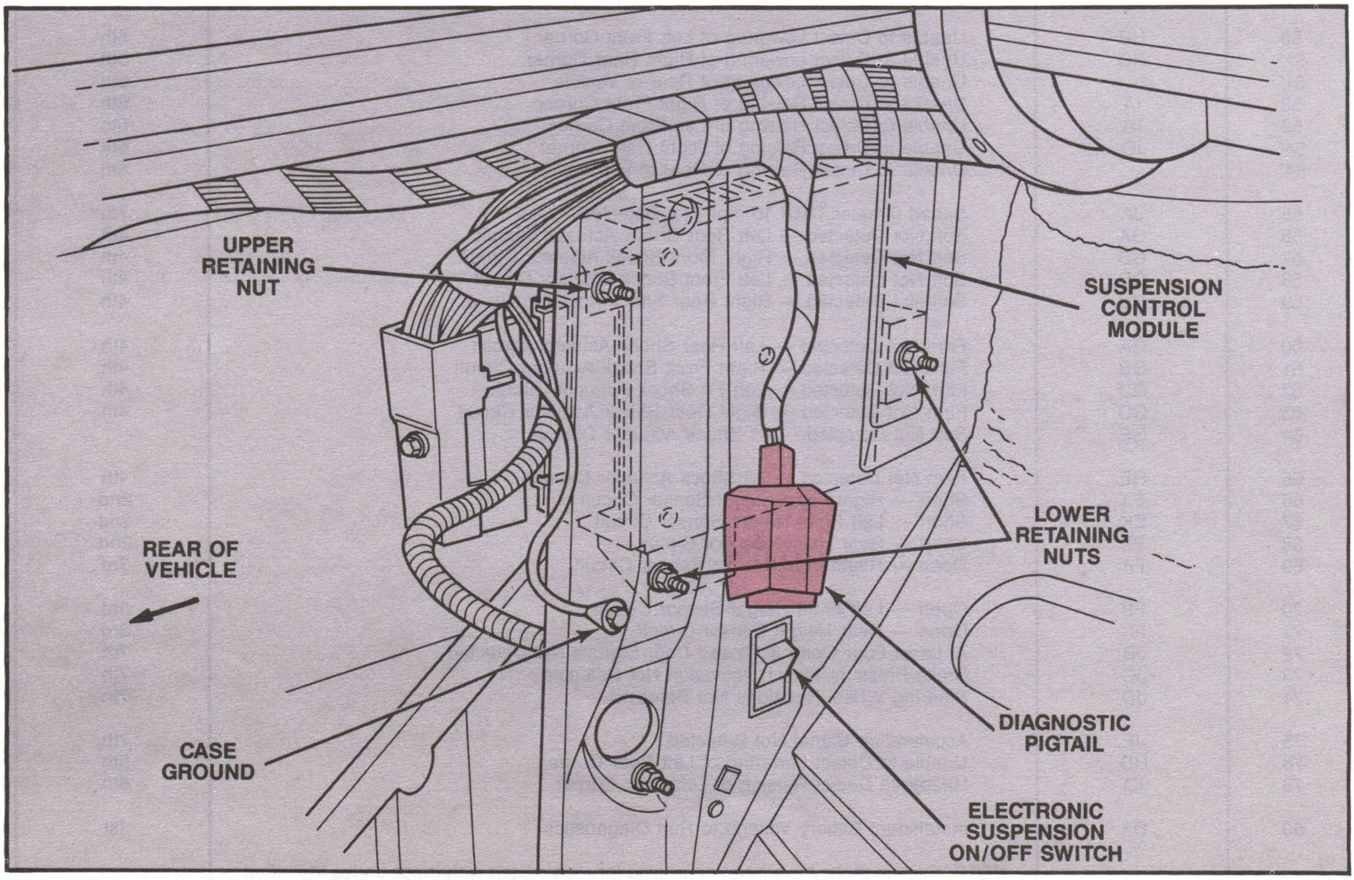


Figure 99—Suspension On/Off Switch

STAR CODE	PINPOINT PROCEDURE	DESCRIPTION	SERVICE PRIORITY
10		Service Bay Diagnostics Entered	
11		System Checked Out Okay	
12		Automatic Test Completed — No Faults Detected — Perform Manual Inputs	
13		Automatic Test Completed — Faults Detected — Perform Manual Inputs	
15		No Faults Detected	
21		Vent Right Front Air Spring	
22		Vent Left Front Air Spring	
23		Vent Right Rear Air Spring	
24		Inflate Right Front Air Spring	
25		Inflate Left Front Air Spring	
26		Inflate Right Rear Air Spring	
27		Vent Left Rear Air Spring	
28		Inflate Left Rear Air Spring	
31		Air Compressor Toggle	
32		Vent Solenoid Valve Toggle	
33		Air Spring Solenoid Valve Toggle	
34		Shock Actuator Toggle (Firm/Soft)	
35		Door Open & Door Closed Detection	
40	EA	Short — Left Front Air Spring Solenoid Valve Circuit	2nd
41	EB	Short — Right Front Air Spring Solenoid Valve Circuit	2nd
42	EC	Short — Left Rear Air Spring Solenoid Valve Circuit	2nd
43	ED	Short — Right Rear Air Spring Solenoid Valve Circuit	2nd
44	EE	Short — Vent Solenoid Valve Circuit	2nd
45	EF	Short — Air Compressor Relay Circuit	2nd
46	EG	Short — Height Sensor Power Supply Circuit	2nd
47	EH	Short — Soft Shock Actuator Relay Circuit	2nd
48	EI	Short — Firm Shock Actuator Relay Circuit	2nd
49	HA	Unable to Detect Lowering of Right Front Corner	5th
50	HB	Unable to Detect Lowering of Left Front Corner	5th
51*	HC	Unable to Detect Lowering of Right Rear Corner	5th
51*		Unable to Detect Lowering of Rear of Vehicle	5th
52	IA	Unable to Detect Raising of Right Front Corner	6th
53	IB	Unable to Detect Raising of Left Front Corner	6th
54*	IC	Unable to Detect Raising of Right Rear Corner	6th
54*		Unable to Detect Raising of Rear of Vehicle	6th
55	JA	Speed Greater Than 15 mph Not Detected	7th
56	GA	Soft Not Detected — Left Rear Shock Actuator Circuit	4th
57	GB	Soft Not Detected — Right Front Shock Actuator Circuit	4th
58	GC	Soft Not Detected — Left Front Shock Actuator Circuit	4th
59	GD	Soft Not Detected — Right Rear Shock Actuator Circuit	4th
60	GA	Firm Not Detected — Left Rear Shock Actuator Circuit	4th
61	GB	Firm Not Detected — Right Front Shock Actuator Circuit	4th
62	GC	Firm Not Detected — Left Frt Shock Actuator Circuit	4th
63	GD	Firm Not Detected — Right Rear Shock Actuator Circuit	4th
64	GE	Soft Not Detected — All Shock Actuator Circuits	
65	GE	Firm Not Detected — All Shock Actuator Circuits	4th
66	EJ	Short — Right Front Height Sensor Circuit	2nd
67	EK	Short — Left Front Height Sensor Circuit	2nd
68	EL	Short — Rear Height Sensor Circuit	2nd
69	FA	Open — Rilght Front Height Sensor Circuit	3rd
70	FB	Open — Left Front Height Sensor Circuit	3rd
71	FC	Open — Rear Height Sensor Circuit	3rd
72	JB	At Least Four Open & Closed Door Signals Not Detected	7th
73	JC	Brake Pressure Switch Activation Not Detected	7th
74	JD	Steering Wheel Rotations Not Detected	7th
75	JE	Acceleration Signal Not Detected	7th
78	HD	Unable to Detect Lowering of Left Rear Corner	5th
79	ID	Unable to Detect Raising of Left Rear Corner	6th
80	DA	Insufficient Battery Voltage to Run Diagnostics	1st
		NOTE: System faults have been prioritized for repair. Start with those codes identified with a service priority of: 1st, then 2nd, then 3rd, . . . and finally 7th.	

Figure 100 — Air Suspension Fault Codes

Fault Code Display — The fault codes can be displayed at this time using the STAR Tester. Each fault code detected will be displayed for about 15 seconds. The code display will continue until they are no longer needed. The codes should be written down at this time.

Functional Tests — The fault codes recorded during the Drive Cycle diagnosis should be compared to the fault codes recorded during Service Bay diagnosis. The codes which appear during both tests are hard faults. The codes appearing only in the Drive Cycle diagnostics are intermittent faults.

Each fault code (Fig. 100) has its own pinpoint test. These tests have priorities assigned to them with "1" being the highest priority and "7" being the lowest priority. One fault may cause other fault codes to be displayed. Perform the Pinpoint tests in order of priority starting with the highest priority.

The chart (p. 98) explains how the air suspension system is tested for Drive Cycle Diagnostics, Service Bay Diagnostics and Spring Fill Diagnostics. Refer to the Continental Shop Manual, Section 14-40-34 for Pinpoint Tests.

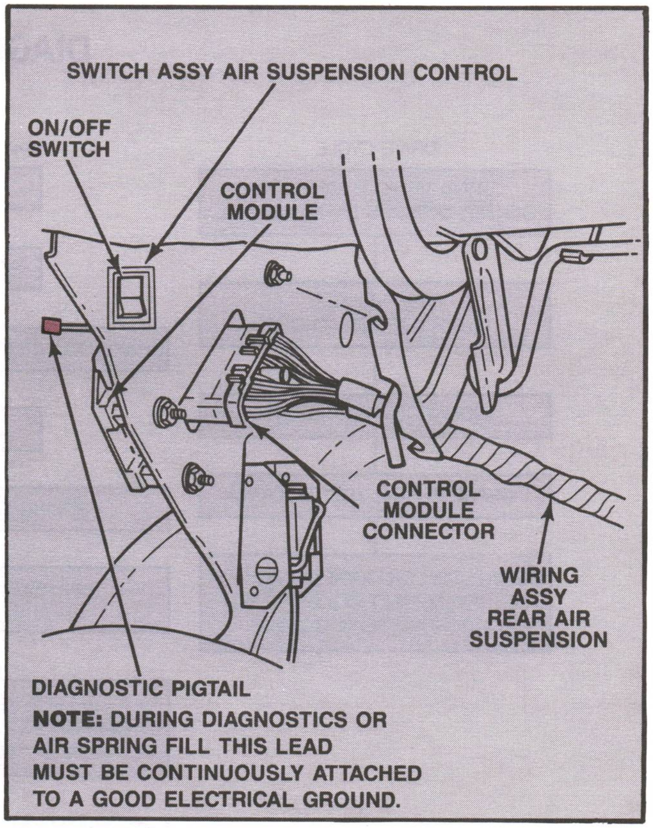

SWITCH ASSY AIR SUSPENSION CONTROL
ON/OFF SWITCH
CONTROL MODULE
CONTROL MODULE CONNECTOR
WIRING ASSY REAR AIR SUSPENSION
DIAGNOSTIC PIGTAIL
NOTE: DURING DIAGNOSTICS OR AIR SPRING FILL THIS LEAD MUST BE CONTINUOUSLY ATTACHED TO A GOOD ELECTRICAL GROUND.

Figure 101 — On/Off Switch, Control Module, and Diagnostic Connector.

Mark VII Air Suspension System Diagnostics

The Air Suspension system in use on the Mark VII and some Continental models is a fairly complicated system to test as there are 10 specific diagnostic tests that check the system out. Before attempting the tests it is important to be aware of some specific components.

This system is equipped with an ON/OFF switch, located with the control module and diagnostic connector in the luggage compartment (Fig. 101).

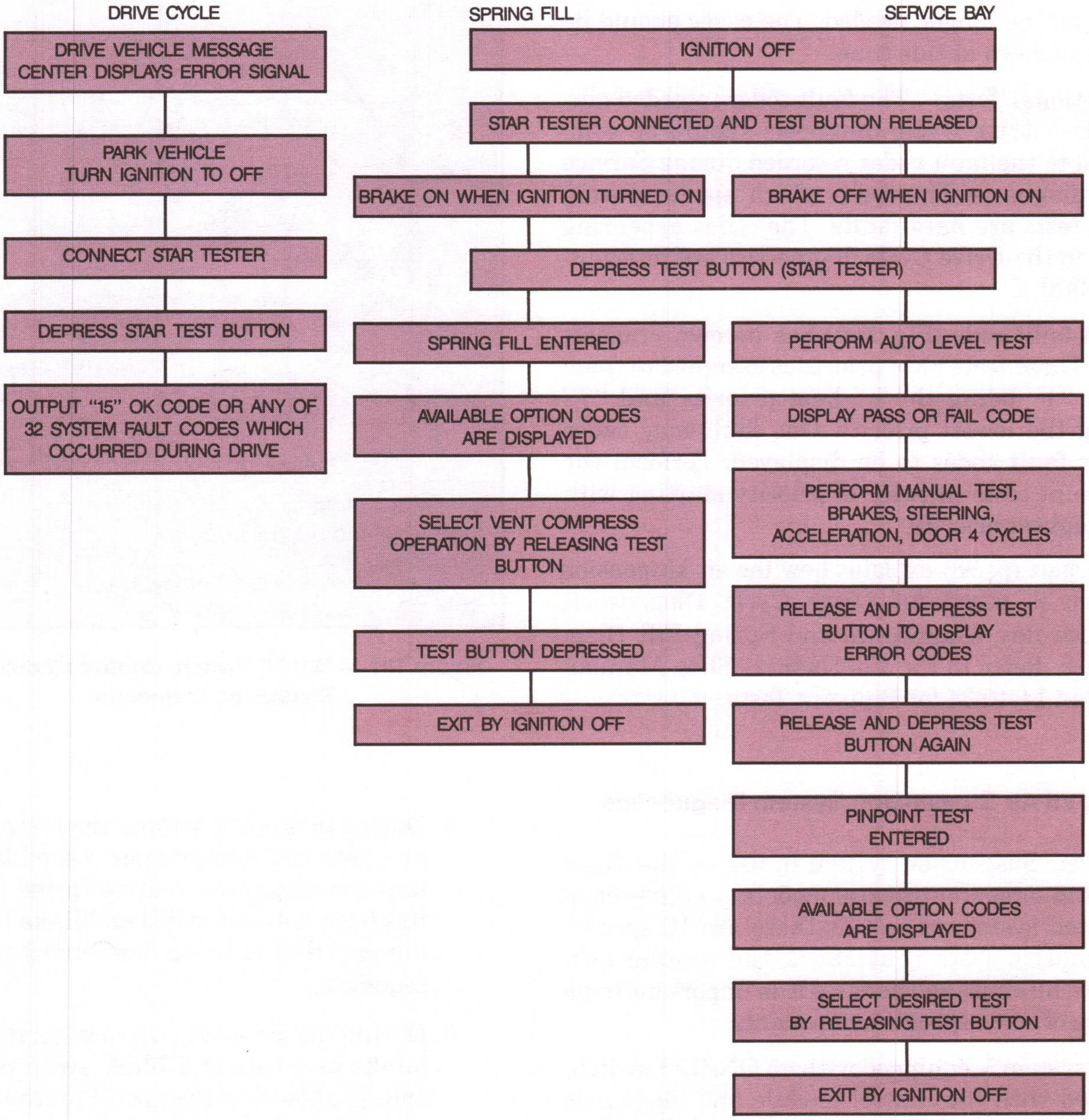
There is also an air suspension warning lamp mounted on the overhead console. In some instances, the warning lamp can be used as a diagnostic aid. The warning lamp has three main functions:

1. During normal operation with the ignition in the RUN position, the lamp glowing continuously indicates a possible air suspension system malfunction.
2. During diagnostic testing the lamp blinks at a rate of 1.8 blinks per second to show that the diagnostic routine in the module has been entered and then blinks the test number that is being run during the test sequence.
3. During the air spring fill routine, the lamp blinks at a rate of 1 blink every two seconds to show that the air fill routine in the module has been entered.

Specific conditions relating to system operation are also evident on the lamp. These include:

- **On a vehicle operating normally, the warning lamp will glow for approximately one second and then go out when the ignition is turned from the OFF to RUN position. The lamp does not operate when the ignition is in either the OFF or START position.**

DIAGNOSTICS


DRIVE CYCLE
DRIVE VEHICLE MESSAGE CENTER DISPLAYS ERROR SIGNAL
PARK VEHICLE TURN IGNITION TO OFF
CONNECT STAR TESTER
DEPRESS STAR TEST BUTTON
OUTPUT "15" OK CODE OR ANY OF 32 SYSTEM FAULT CODES WHICH OCCURRED DURING DRIVE
SPRING FILL
SERVICE BAY
IGNITION OFF
STAR TESTER CONNECTED AND TEST BUTTON RELEASED
BRAKE ON WHEN IGNITION TURNED ON
BRAKE OFF WHEN IGNITION ON
DEPRESS TEST BUTTON (STAR TESTER)
SPRING FILL ENTERED
AVAILABLE OPTION CODES ARE DISPLAYED
SELECT VENT COMPRESS OPERATION BY RELEASING TEST BUTTON
TEST BUTTON DEPRESSED
EXIT BY IGNITION OFF
PERFORM AUTO LEVEL TEST
DISPLAY PASS OR FAIL CODE
PERFORM MANUAL TEST, BRAKES, STEERING, ACCELERATION, DOOR 4 CYCLES
RELEASE AND DEPRESS TEST BUTTON TO DISPLAY ERROR CODES
RELEASE AND DEPRESS TEST BUTTON AGAIN
PINPOINT TEST ENTERED
AVAILABLE OPTION CODES ARE DISPLAYED
SELECT DESIRED TEST BY RELEASING TEST BUTTON
EXIT BY IGNITION OFF

TEST NUMBER	TEST DESCRIPTION	SERVICE DETECTION
1	Rear air springs are overfilled to a high vehicle position, vented to low vehicle position and then refilled to a trim position, to verify height sensor signals	Service indicator light glows if proper signal from sensor is not received during each section of test
2	Right front air spring is overfilled to a high vehicle position, vented to low vehicle position and then refilled to a trim position, to verify height sensor signals	Service indicator light glows if proper signal from sensor is not received during each section of test
3	Left front air spring is overfilled to a high vehicle position, vented to low vehicle position and then refilled to a trim position, to verify height sensor signals	Service indicator light glows if proper signal from sensor is not received during each section of test
4	Compressor motor is cycled on and off	If audible "hum" of compressor motor is not heard, motor or compressor circuit may be source of problem.
5	Air vent valve is cycled on and off	If audible "click" of valve is not heard, valve or circuit may be problem.
6 7 8 9	Each air spring valve is cycled on and off in the following order: LF, RF, RR, LR, and the Air Vent Valve	If audible "click" of valve is not heard, valve or circuit may be problem. If the body does not lower at the wheel being tested, a blocked air line or compressor dryer may be the problem
10	Checks brake circuits and removes module from diagnostic sequence	Service indicator light continues to flash

Figure 102 — Test Chart

- **If the lamp does not go out after turning the ignition from the OFF to the RUN position, it indicates no battery power to the module.**
- **If the lamp glows for approximately 1/2 second, goes out, and then glows continuously after 5 — 8 seconds, when the ignition is turned from the OFF to RUN position, a height sensor or harness malfunction is indicated.**
- **After the ignition is turned from the OFF to RUN position, if the lamp comes on and glows continuously at any time after 8 seconds, a system malfunction is indicated.**
- **Once the warning lamp comes on during an ignition ON cycle, it will glow continuously for that ignition ON cycle.**
- **Erratic operation of the warning lamp (blinking or occasional flashing) during an ignition ON cycle indicates a system malfunction.**

As stated earlier, the diagnostic sequence for this test has 10 parts. The first three tests are controlled by the module which will make the pass-/fail decisions. Tests 4 through 10 require pass/fail decisions to be made by the technician. The actual components being checked in each test are shown on the following chart (Fig. 102) and its accompanying illustration (Fig. 103).

Diagnostic Test Sequence

Use the following procedures to test the Mark VII air suspension system.

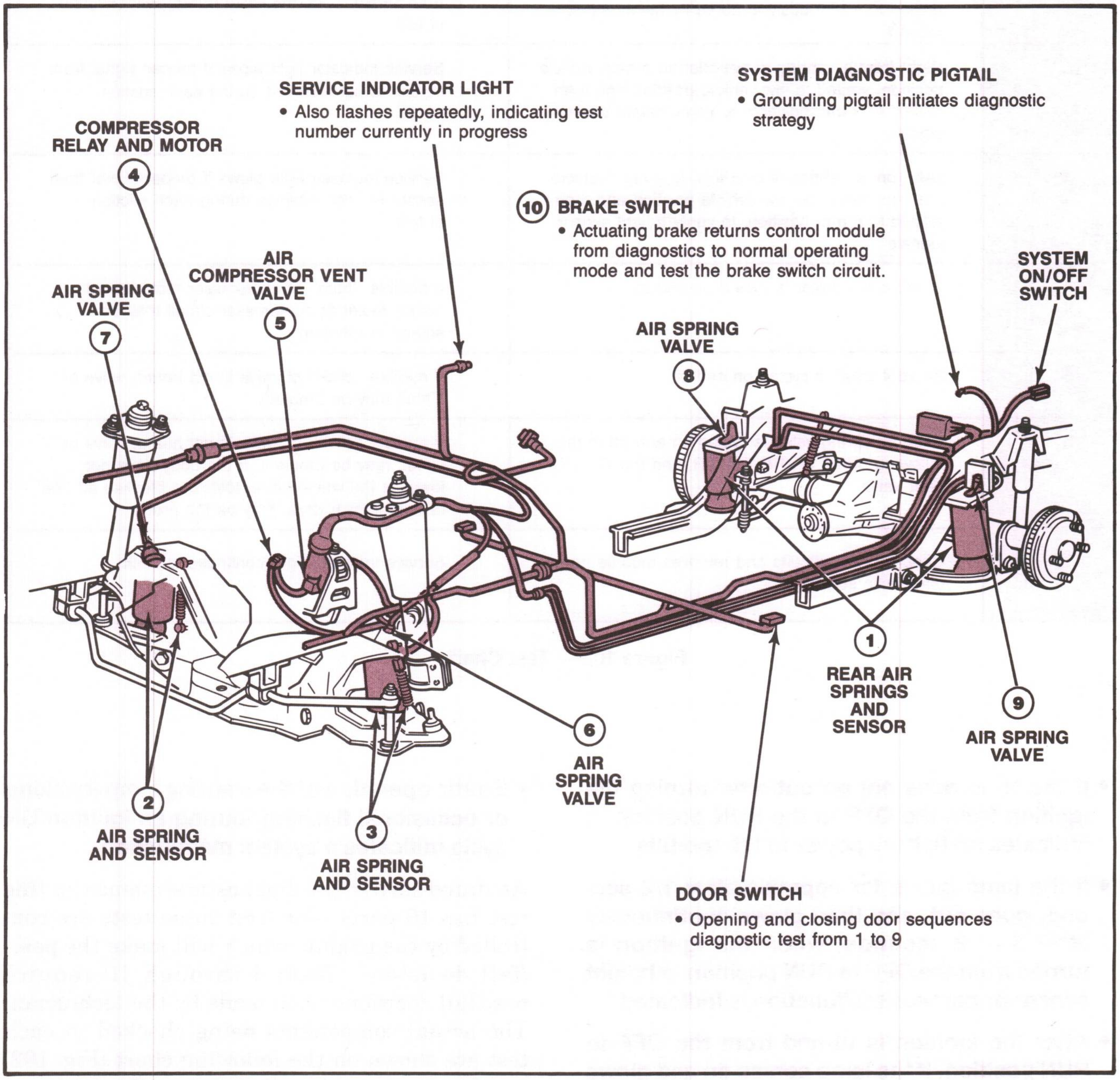

SERVICE INDICATOR LIGHT
• Also flashes repeatedly, indicating test number currently in progress
SYSTEM DIAGNOSTIC PIGTAIL
• Grounding pigtail initiates diagnostic strategy
COMPRESSOR RELAY AND MOTOR
4
10 BRAKE SWITCH
• Actuating brake returns control module from diagnostics to normal operating mode and test the brake switch circuit.
SYSTEM ON/OFF SWITCH
AIR SPRING VALVE
7
AIR COMPRESSOR VENT VALVE
5
AIR SPRING VALVE
8
1
REAR AIR SPRINGS AND SENSOR
9
AIR SPRING VALVE
6
AIR SPRING VALVE
2
AIR SPRING AND SENSOR
3
AIR SPRING AND SENSOR
DOOR SWITCH
• Opening and closing door sequences diagnostic test from 1 to 9

Figure 103 — Components Being Tested

DIAGNOSTIC TEST SEQUENCE

VEHICLE PREPARATION

1. Check vehicle for overloading
   - ☐ Check vehicle passenger compartment and trunk for loads
   - ☐ Remove all loads; vehicle must be at curb weight

2. Check service indictor light function
   - ☐ Turn ignition switch to RUN position and observe indicator light function:
     - ☐ Flashes once and goes out .... OK
     - ☐ Comes on and remains on .... CHECK:
       - Air suspension service switch (must be on)
       - Switch feed circuit
     - ☐ Does not flash or come on .... CHECK:
       - Switch feed circuit
       - Indicator bulb
       - Door switches
       - Fuse in ignition circuit 687
       - Bulb feed circuit
       - Bulb circuit to module
       - Ignition circuit 687
     - ☐ Turn ignition to OFF position ....

NOTE: Connect a battery charger and a voltmeter to the battery; leave them connected for the duration of the test sequence.

CAUTION: If the voltmeter reading drops below 12 volts during the test sequence, increase the rate of charge. If the voltage level is allowed to drop below this level, damage to the compressor motor or relay may result.

3. Level vehicle
   - ☐ Driver door closed with window open
   - ☐ Set parking brake
   - ☐ Service brake off
   - ☐ Reach through open window and turn ignition key to RUN position for minimum of five minutes; then turn ignition key to OFF

NOTE: The door must remain closed, or the module will not service down signals from the height sensors.

DIAGNOSTIC TEST SEQUENCE

4. Enter diagnostic sequence
   - ☐ Check that diagnostic pigtail is ungrounded
   - ☐ Turn ignition switch to OFF position
   - ☐ Ground diagnostic pigtail; if already grounded, unground and ground again

NOTE: If the test sequence is to be conducted while sitting in the driver's seat, a long jumper wire can be connected from the diagnostic pigtail to the driver's seat, where a suitable ground can be found.

☐ Turn ignition switch to RUN position and observe service indicator light function:

- ☐ Flashes once and goes out .... CHECK:
  - Pigtail connection
- ☐ Comes on and remains on .... CHECK:
  - Indicator light circuit
  - Module battery circuit
- ☐ Flashes .... DIAGNOSTICS ENTERED

NOTE: After the diagnostic sequence is entered, do not open the door, press the brake pedal, or start the engine unless you are specifically instructed to do so.

If a system problem is isolated and repaired during the test sequence, always repeat the test to verify proper system operation. The sequence cannot be entered at random. To test the operation of a specific subsystem or component, you must begin with Test 1. To speed up the test sequence, open and close the door or press the courtesy light switch until the indicator light flashes the required test number.

DIAGNOSTIC TEST SEQUENCE

TEST 1 - REAR SUSPENSION SYSTEM

Enter Test 1

☐ Open and close door once

The service indicator light will flash on and off with a pause between each flash. Watch the light and let the test proceed. If a failure occurs, this test can be repeated using the System Performance Checklist below to help isolate the subsystem problem, or Test 2 can be performed.

Test Results

☐ Test 1 completed and light continues to flash test number (one flash) Test 1 passed; proceed to Test 2

☐ Light on, no flash Test 1 failed; repeat Test 1 using System Performance Checklist below, or proceed to Test 2

☐ Light flashes rapidly (4/sec.) Test 1 failed; repeat Test 1 using System Performance Checklist below, or proceed to Test 2

System Performance Checklist

	YES	NO
1. Compressor relay clicks closed (hand felt)	☐	Go to Shop Manual Pinpoint Tests
2. Compressor cuts in	☐	Go to Shop Manual Pinpoint Tests
3. Rear air spring valve click open	☐	Go to Shop Manual Pinpoint Tests
4. Vehicle rises for 15-30 seconds; sensor signals that vehicle is high (The compressor should cut out) . . .	☐	Go to Shop Manual Pinpoint Tests
5. Air vent valve clicks open and vehicle lowers for a maximum of 30 seconds; sensor signals that vehicle is low. (The air vent valve should click closed and the compressor should cut in)	☐	Go to Shop Manual Pinpoint Tests
6. Vehicle rises back to trim height; sensor signals vehicle is at trim height (Rear air spring valve should click closed and compressor should cut out)	☐	Go to Shop Manual Pinpoint Tests

TEST 2 - RIGHT FRONT SUSPENSION SYSTEM

Enter Test 2

☐ Test 1 passed Open and close door once
☐ Test 1 failed Open and close door twice

The service indicator light will flash two times with a pause occurring between each series of flashes. Watch the light and let the test proceed. If a failure occurs, this test can be repeated using the System Performance Checklist below to help isolate the subsystem problem, or Test 3 can be performed.

Test Results

☐ Test 2 completed and light continues to flash test number (two flashes) Test 2 passed; proceed to Test 3
☐ Light on, no flash Test 2 failed; repeat Test 2 using System Performance Checklist below, or proceed to Test 3
☐ Light flashes rapidly (4/sec.) Test 2 failed; repeat Test 2 using System Performance Checklist below, or proceed to Test 3

System Performance Checklist

	YES	NO
1. Compressor relay clicks closed (hand felt)	☐	Go to Shop Manual Pinpoint Tests
2. Compressor cuts in	☐	Go to Shop Manual Pinpoint Tests
3. Right front air spring valve clicks open	☐	Go to Shop Manual Pinpoint Tests
4. Vehicle rises for 15-30 seconds; sensor signals that vehicle is high. (The compressor should cut out)	☐	Go to Shop Manual Pinpoint Tests
5. Air vent valve clicks open and vehicle lowers for a maximum of 30 seconds; sensor signals that vehicle is low. (The air vent valve should click closed and the compressor should cut in)	☐	Go to Shop Manual Pinpoint Tests
6. Vehicle rises back to trim height; sensor signals vehicle is at trim height (Right front air spring valve should click closed and compressor should cut out)	☐	Go to Shop Manual Pinpoint Tests

TEST 3 - LEFT FRONT SUSPENSION SYSTEM

Enter Test 3

☐ Test 2 passed Open and close door once
☐ Test 2 failed Open and close door twice

The service indicator light will flash three times with a pause occurring between each series of flashes. Watch the light and let the test proceed. If a failure occurs, this test can be repeated using the System Performance Checklist below to help isolate the subsystem problem, or Test 4 can be performed.

Test Results

☐ Test 3 completed and light continues to flash test number 3 times Test 3 passed; proceed to Test 4
☐ Light on, no flash Test 3 failed; repeat Test 3 using System Performance Checklist below, or proceed to Test 4
☐ Light flashes rapidly (4/sec.) Test 3 failed; repeat Test 3 using System Performance Checklist below, or proceed to Test 4

System Performance Checklist

	YES	NO
1. Compressor relay clicks closed (hand felt)	☐	Go to Shop Manual Pinpoint Tests
2. Compressor cuts in	☐	Go to Shop Manual Pinpoint Tests
3. Left front air spring valve clicks open	☐	Go to Shop Manual Pinpoint Tests
4. Vehicle rises for 15-30 seconds; sensor signals that vehicle is high (The compressor should cut out) . . .	☐	Go to Shop Manual Pinpoint Tests
5. Air vent valve clicks open and vehicle lowers for a maximum of 30 seconds; sensor signals that vehicle is low. (The air vent valve should click closed and the compressor should cut in)	☐	Go to Shop Manual Pinpoint Tests
6. Vehicle rises back to trim height; sensor signals vehicle is at trim height (Left front air spring valve should click closed and compressor should cut out)	☐	Go to Shop Manual Pinpoint Tests

TEST 4 - COMPRESSOR RELAY AND COMPRESSOR

NOTE: During Tests 4 through 9, the service indicator light will flash only the test number. These tests operate individual system components, and test results will no longer be related to the indicator light. Isolating a system problem is now related to sounds created by the compressor motor and the "clicking" of the individual valves as they open and close. The service indicator light will flash the test number with a slight pause occurring between each series of flashes. If the indicator light fails to flash the test number, check the pigtail ground, indicator light bulb, and bulb circuit.

Enter Test 4

☐ Test 3 passed	Open and close door once
☐ Test 3 failed	Open and close door twice

The service indicator light will continuously flash four times to indicate the test number.

System Performance Checklist

	YES	NO
1. Compressor relay clicks closed (hand felt)	☐	Go to Shop Manual Pinpoint Tests
2. Compressor cuts in and cycles on and off	☐	Go to Shop Manual Pinpoint Tests

NOTE: The compressor will cycle on and off for a maximum of 50 cycles. Conclusive test results do not require the completion of all 50 cycles. If the light flashes the test number several times and the compressor continues to cycle, proceed to Test 5.

NOTE: The rear of the vehicle may rise during this test.

TEST 5 - AIR VENT VALVE

Enter Test 5

☐ Open and close door once (even though test 4 may have failed)

The service indicator light will continuously flash five times to indicate the test number.

System Performance Checklist

	YES	NO
1. Clicking of air vent valve opening and closing can be heard	☐	Go to Shop Manual Pinpoint Tests

TEST 6 - LEFT FRONT AIR SPRING VALVE

Enter Test 6

☐ Open and close door once

The service indicator light will continuously flash six times to indicate the test number.

System Performance Checklist

	YES	NO
1. Air vent valve clicks open	☐	Go to Shop Manual Pinpoint Tests
2. Air spring valve clicks open and closed (air can be heard escaping through air vent valve)	☐	Go to Shop Manual Pinpoint Tests

NOTE: Because air is escaping from the air spring, the left front corner of the vehicle will lower. If the vent and air spring valves click, but air does not escape through the air vent, look for a pinched or plugged air line.

TEST 7 - RIGHT FRONT AIR SPRING VALVE

Enter Test 7

☐ Open and close door once

The service indicator light will continuously flash seven times to indicate the test number.

System Performance Checklist

	YES	NO
1. Air vent valve clicks open	☐	Go to Shop Manual Pinpoint Tests
2. Air spring valve clicks open and closed (air can be heard escaping through air vent valve	☐	Go to Shop Manual Pinpoint Tests

NOTE: Because air is escaping from the air spring, the right front corner of the vehicle will lower. If the vent and air spring valves click, but air does not escape through the vent, look for a pinched or plugged air line.

TEST 8 - RIGHT REAR AIR SPRING VALVE

Enter Test 8

☐ Open and close door once

The service indicator light will continuously flash eight times to indicate the test number.

System Performance Checklist

	YES	NO
1. Air vent valve clicks open	☐	Go to Shop Manual Pinpoint Tests
2. Air spring valve clicks open and closed (air can be heard escaping through air vent valve)	☐	Go to Shop Manual Pinpoint Tests

NOTE: Because air is escaping from the air spring, the right rear corner of the vehicle will lower. If the vent and air spring valves click, but air does not escape through the air vent, look for a pinched or plugged air line.

TEST 9 - LEFT REAR AIR SPRING VALVE

Enter Test 9

☐ Open and close door once

The service indicator light will continuously flash nine times to indicate the test number.

System Performance Checklist

	YES	NO
1. Air vent valve clicks open	☐	Go to Shop Manual Pinpoint Tests
2. Air spring valve clicks open and closed (air can be heard escaping through air vent valve	☐	Go to Shop Manual Pinpoint Tests

NOTE: Because air is escaping from the air spring, the right front corner of the vehicle will lower. If the vent and air spring valves click, but air does not escape through the vent, look for a pinched or plugged air line.

TEST 10 - BRAKE CIRCUIT AND REMOVAL OF MODULE FROM DIAGNOSTIC SEQUENCE

Enter Test 10

☐ Open and close door once

The service indicator light will continuously flash 10 times to indicate the test number.

☐ Press brake pedal

The service indicator light will flash once and then turn off.

System Performance Checklist

	YES	NO
1. Indicator light flashes once and turns off	☐	Go to Shop Manual Pinpoint Tests CHECK:SHOP MANUAL • Brake switch feed circuit • Brake circuit to module

NOTE: After completion of the diagnostic sequence, unground the diagnostic pigtail.

GLOSSARY

Actuating Device - An electromechanical device that follows instructions from the control module and puts them into action.

Air Spring - A type of automotive suspension spring which relies on a membrane filled with air to perform the same function of a typical leaf or coil spring.

ARC - Automatic Ride Control.

Brake Sensor Switch - A switch assembly that detects when heavy braking occurs and provides this information to the control module.

Calibration - A fixed setting.

Coil Spring - A type of suspension spring made of coiled steel.

Control Module - A semiconductor microprocessor device that is used to control the action of a steering and/or suspension system.

Counter-Balancing Torsion Spring - A spring that first came into use during the 1988 model year on the Continental. This spring provides an outward force on the MacPherson strut to offset the twisting forces that are induced by the road on the wheel.

Dive - A suspension system condition caused by heavy braking. During this condition the front suspension is severely compressed by rapid deceleration.

Dual Dampening - A shock or strut which has two separate calibrations.

ECA - Electronic Control Assembly.

EVO - Electronic Variable Orifice.

Height Sensor - A sensor that detects vehicle trim height.

Jounce - The suspension condition which causes spring compression.

Lateral Acceleration - Acceleration to the side, not straight ahead.

Leaf Spring - A type of suspension spring made up of a group of metal leafs.

Load Compensation - Action of a suspension system to maintain vehicle trim height when weight is placed on the vehicle.

PRC - Programmed Ride Control.

Rack and Pinion Steering Gear - A steering gear in which a pinion gear attached to the steering shaft transfers steering wheel motion to a rack. The rack is attached to the steering linkage.

Rebound - The expansion of a suspension spring that results from jounce.

Recalibration - A change in calibration.

Recirculating Ball Steering Gear - A steering gear which utilizes a series of recirculating balls on a worm gear to transfer steering wheel movement to an internal rack. The rack in turn applies this movement to a sector shaft attached to the steering linkage.

Ride Control Switch - Switch used to change the suspension setting on an electronically controlled suspension system.

Roll - A suspension system condition caused by high speed maneuvers. During this condition the suspension on one side of the vehicle is severely compressed while the other side is extended. This body movement is caused by centrifugal force.

Rotary Valve - Component within the power steering gear that controls the application of fluid pressure.

Shock Absorber - A hydraulic cylinder used to dampen spring action.

Solenoid Valve - Electrically operated valve assembly.

Spool Valve - A term used in some instances to describe a rotary valve.

Squat - A suspension system condition caused by road undulations. During this condition all springs bottom out.

Steering Wheel Rotation Sensor - A sensor that informs the control module of steering wheel position and also how rapidly the steering wheel is being turned.

Strut - A combination shock absorber and spring assembly.

Undulation - A rapid dip or rise in a road surface.

VAPS - Variable Assist Power Steering.

Vehicle Speed Sensor - Input to the control module that informs it of the speed the vehicle is travelling.

Vent Solenoid - A solenoid assembly placed on an air compressor in an air suspension system that vents excess pressure from the system when instructed to do so by the control module. The vent solenoid also maintains a minimum pressure within the system.

NOTES

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NOTES

QUIZ
1989-6

COMPREHENSIVE TRAINING PROGRAM
FORD PARTS AND SERVICE DIVISION

Electronic Steering And Suspension Systems

QUIZ
1989-6

INSTRUCTIONS: Place a circle around the letter preceding the correct answer as shown below.

QUESTION: Air Springs are considered part of the:
[✓ a.] Suspension System b. Steering System c. Emission Control System d. Exhaust System

1. Which of the following sensors utilizes a photocell?
   a. Height Sensor
   b. Vehicle Speed Sensor
   c. Steering Sensor
   d. Brake Pressure Sensor

2. Which one of the following vehicles has the vehicle speed sensor integral with the speedometer?
   a. Mark VII
   b. Probe GT
   c. Super Coupe/XR7
   d. Continental

3. On the EVO steering system, where is the actuator located?
   a. Steering Gear
   b. Frame
   c. Engine Block
   d. Power Steering Pump

4. Which one of the following vehicles uses the same module to control the EVO steering system and ARC suspension system?
   a. Super Coupe/XR7
   b. Mark VII
   c. Continental
   d. Crown Victoria/Grand Marquis

5. Which one of the following vehicles has a steering control module with three settings, High, Normal and Low?
   a. Super Coupe/XR7
   b. Probe GT
   c. Thunderbird LX/Cougar LS
   d. Continental

6. Where is the diagnostic connector located for the EVO steering system on the Thunderbird LX and Cougar LS?
   a. Beneath the ash tray in the center console
   b. Near the right front shock tower
   c. Left side of the luggage compartment
   d. Above the glove compartment

7. Which one of the following switch/sensors are not used by the Automatic Ride Control system to determine when a shift should be made from Normal to Firm?
   a. Neutral Safeety Switch
   b. Super Charger Boost Sensor
   c. Vehicle Speed Sensor
   d. Steering Wheel Sensor

8. Where is the air suspension system ON/OFF switch located on the Mark VII?
   a. Engine Compartment
   b. Glove Compartment
   c. Luggage Compartment
   d. Center Console

9. You are diagnosing a malfunction in the Programmed Ride Control System of a 1989 Probe GT. During which part of the Quick Test is it necessary to run the steering wheel?
   a. No portion of the test requires the steering wheel to be turned.
   b. Part A
   c. Part B
   d. Part C

10. During system diagnostics on the Mark VII air suspension system there is an occasion when the air suspension warning lamp on the overhead console blinks at 1.8 blinks per second. What does this blinking indicate?
    a. Diagnostic routine in the module has been entered
    b. There is a malfunction in the module
    c. There is a system malfunction
    d. No problem detected

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